Vol. 13, No. 5 May, 1957

LUBRICATION ENGINEERING

RESEARCH APPLICATION EDUCATION MAINTENANCE

Testing a High-Speed Bearing
(Cover Story, p. 294)

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

Here's how centralized lubrication savings soon pay for a Farval system

FARVAL—
Studies in Centralized Lubrication
No. 200

● Interested in a system that produces savings to pay for itself in a few months? And protects your investment in expensive equipment for ten, twenty, or even thirty years or more?

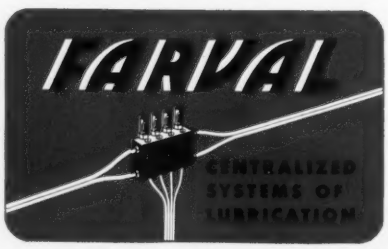
If so, you'll want this new Farval Bulletin 101. It illustrates and describes the application of Farval Centralized Lubrication Systems to a dozen types of equipment—draglines, shovels, crushers, mills, cranes, conveyors and other machinery used in the non-metallic producing and processing industries.

Millions of industrial bearings are protected by Farval. Thousands of new systems go in each year—on equipment both new and old. Farval always pays its way. You'll want the whole story. Why not investigate? Then invest!

Write for Bulletin 101 today. The Farval Corporation, 3267 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

Proved in 30 years of service, Farval manual and automatic centralized lubrication systems protect bearings of thousands of machines in industry. Wherever you see the familiar Dualine valve manifolds, dual lubricant lines and central pumping station, you know a machine is being properly lubricated.



LUBRICATION ENGINEERING

RESEARCH APPLICATION EDUCATION MAINTENANCE

Volume 13, No. 5
May, 1957

Table Of Contents

Cam & Tappet Test for Lubricants, II — Wear Evaluation
by E. H. Loeser, S. B. Twiss & D. M. Teague 269

Prevention of Industrial Dermatitis
by M. L. Beardslee 275

Effects of Nuclear Radiation on Lubricants, The
by J. A. King & W. L. R. Rice 279

Use of Rolling Contact Bearings in Low Viscosity Liquid Metal Lubricants
by W. Markert, Jr. & K. M. Ferguson 285

Advertisers' Index 304
ASLE Directory 303
ASLE News Notebook, compiled by R. D. McCormick 261
Book Reviews 257
Coming Events 265
Cover Story (and Cover Picture), submitted by Westinghouse Research Labs 294
Current Literature 284
Editorial: "The Value of Know-How," by A. F. Brewer 253
Lube Lines, by A. F. Brewer 267
Lubrication Abstracts, compiled by the ASLE Abstracts Sub-Committees 290
New Products 259
Patent Abstracts, compiled by Ann Burchick 292
Personals 257
Section News 265
Summaries of Foreign Papers 278
Technical Services Abstracts 291
The Sight Glass 250

LUBRICATION ENGINEERING is published monthly by the American Society of Lubrication Engineers, 84 E. Randolph St., Chicago 1, Illinois. Current-year single copies 75c; previous-years' single copies, if available, $1.00. Annual subscription $6.00 in the United States and Canada, $7.00 in all other countries.

Copyright 1957 by the American Society of Lubrication Engineers. ASLE will not be responsible for statements or opinions presented at its meetings or printed in its publications.

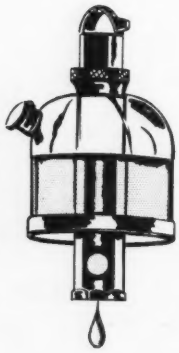
Editor ..... R. K. Gould, The Texas Co., Box 509, Beacon, N. Y.
Associate Editor ..... C. R. Kluge, ASLE National Office, 84 E. Randolph St., Chicago 1, Ill.
Consulting Editor ..... A. F. Brewer, Consultant
Advertising & Business Manager ..... C. L. Willey, ASLE National Office
ASLE Publications Manager ..... R. D. McCormick, ASLE National Office

Editorial Committee

R. K. Gould (Chairman), The Texas Co. ..... R. D. McCormick, ASLE National Office
F. R. Archibald, Arthur D. Little, Inc. ..... J. J. O'Connor, McGraw-Hill Publishing Co.
J. Faust, L. Sonneborn & Sons, Inc. ..... D. W. Sawyer, Aluminum Co. of America
R. H. Josephson, Cleveland Graphite Bronze Co. ..... S. K. Talley, Shell Development Co.
C. R. Lewis, Standard Oil Co. (Ind.) ..... A. C. West, California Research Corp.

Engravings by **Leader Engraving Co.**, Rochelle, Ill.
Printed by **Publishers Printing Co., Inc.**, 112-116 E. Chestnut St., Louisville 2, Ky.
(Second class mail privileges authorized at Chicago, Ill.)

The Sight Glass



Highlights of Articles Scheduled for Coming Issues!

Thermal Conductivity of Aircraft Engine Lubricants at Low Temperature

Thermal conductivities and thermal diffusivities of a representative aircraft-gas-turbine lubricant and a representative piston-engine lubricant were determined over a temperature range of -100° F to 80° F. Average results of 0.75 Btu per hour °F ft for the turbine lubricant vs 0.090 Btu per hr °F ft for the piston lubricant indicate the considerable differences in thermal conductivity between the materials and the hazard in applying existing empirical relationships. The thermal conductivity of the turbine lubricant varied linearly with temperature, while the thermal conductivity of the piston engine lubricant varied irregularly due to wax separation.

Specific Heats of Aircraft Engine Lubricants at Low Temperatures

The design and performance evaluation of aircraft lubricating oil systems depends on a knowledge of the thermal properties of the lubricants. This is the first of a series of papers from a general research program undertaken to satisfy the need for information on thermal properties at low temperatures.

Synthetic Ester Lubricants

Synthetic esters have properties that make them good lubricants under conditions too severe for mineral oils. Early research in Germany led to commercial production, a good part from polyhydric alcohols and monobasic acids. Development in Britain and the USA concentrated on esters derived from monobasic alcohols and dibasic acids. The esters described in the paper improve the lubricity of silicone oils as well as mineral oils.

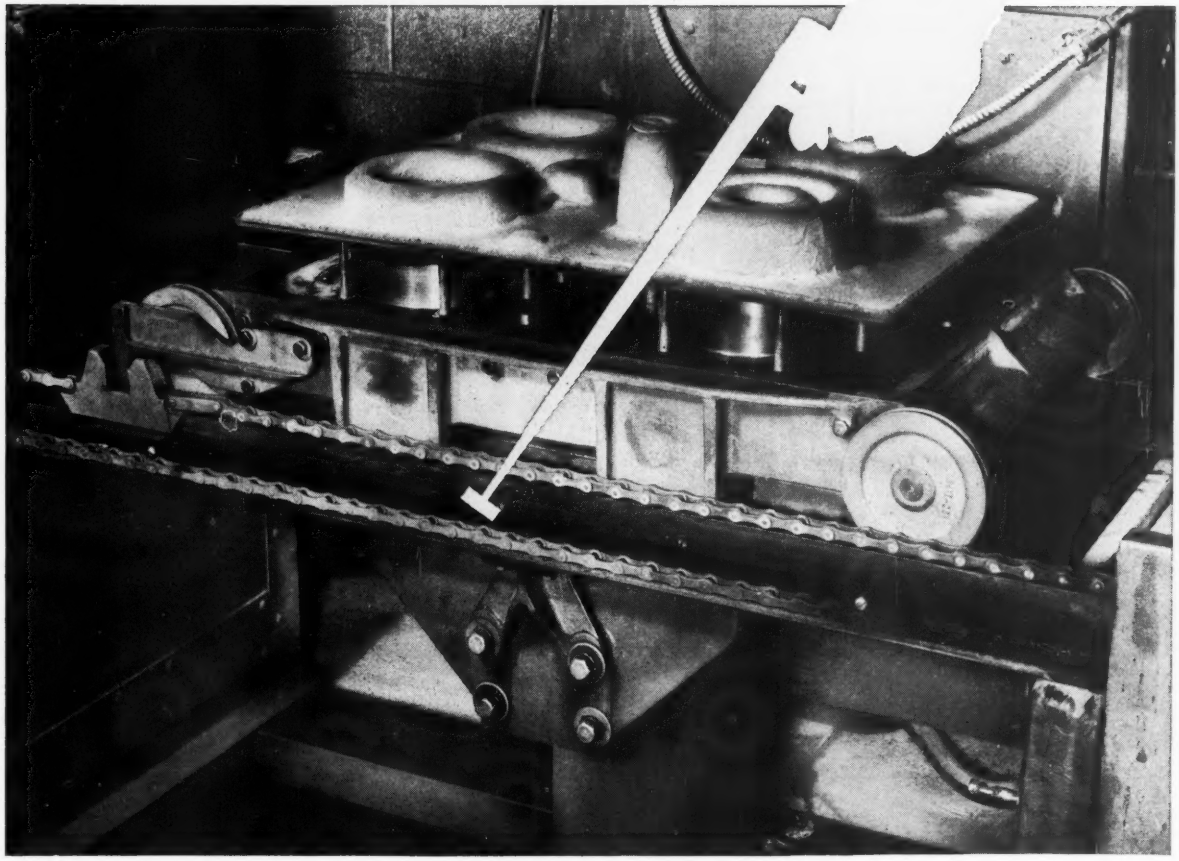
Yield Stress as a Factor in the Performance of Greases

An apparatus for measuring the cone resistance value of a grease as a function of temperature is described. This value is related to the yield stress of the grease. Results show that for a given bearing, if the yield stress of the grease falls below a critical value as a result of the bearing temperature rise, continuous churning of the grease occurs with the production of excessive heat. It is also shown that the dispensability of a grease from a container by pumping can also be calculated from the yield stress. Cone resistance value, therefore, is a useful property for defining the quality of a grease.

Numerical Solution of Reynolds' Equation for Sector Thrust Bearings

A method of solving the Reynolds' equation using digital computer techniques has been developed to predict sector bearing performance. The results compare favorably with experiment and known analytical solutions. The investigation indicates that good design criteria may be established for sector thrust bearings with arbitrary geometries, and possibly very accurate predictions may be obtained if the Reynolds' and energy equations can be solved simultaneously by this technique.

A Touch here does so much



TORRID TRAVELERS

A touch of 'Oildag',® and shell mold pattern carriages keep shuttling smoothly at temperatures of 400°F to 900°F, every 30 seconds, 24 hours a day. Wheels turn freely, hitches drop snugly into place, and chains keep driving; shell molding machines deliver at maximum capacity without interruption.

'Oildag' and other colloidal graphite dispersions are widely used on conveyor systems for glass annealing and for paint and enamel baking ovens where things must keep moving despite high temperatures and hard, continuous service.

In the kilns where porcelain products are fired, temperatures are even higher. Ordinary lubricants burn up, but 'dag'® dispersions keep kiln car wheels turning.

Wherever mechanisms must operate in high temperatures, and ordinary lubricants can't take it, chances are good that one of the many 'dag' dispersions will solve the problem. Talk with your Acheson Service Engineer soon, and write for Bulletin 423 — High Temperature Lubrication. Address Dept. LE-5.

dag®

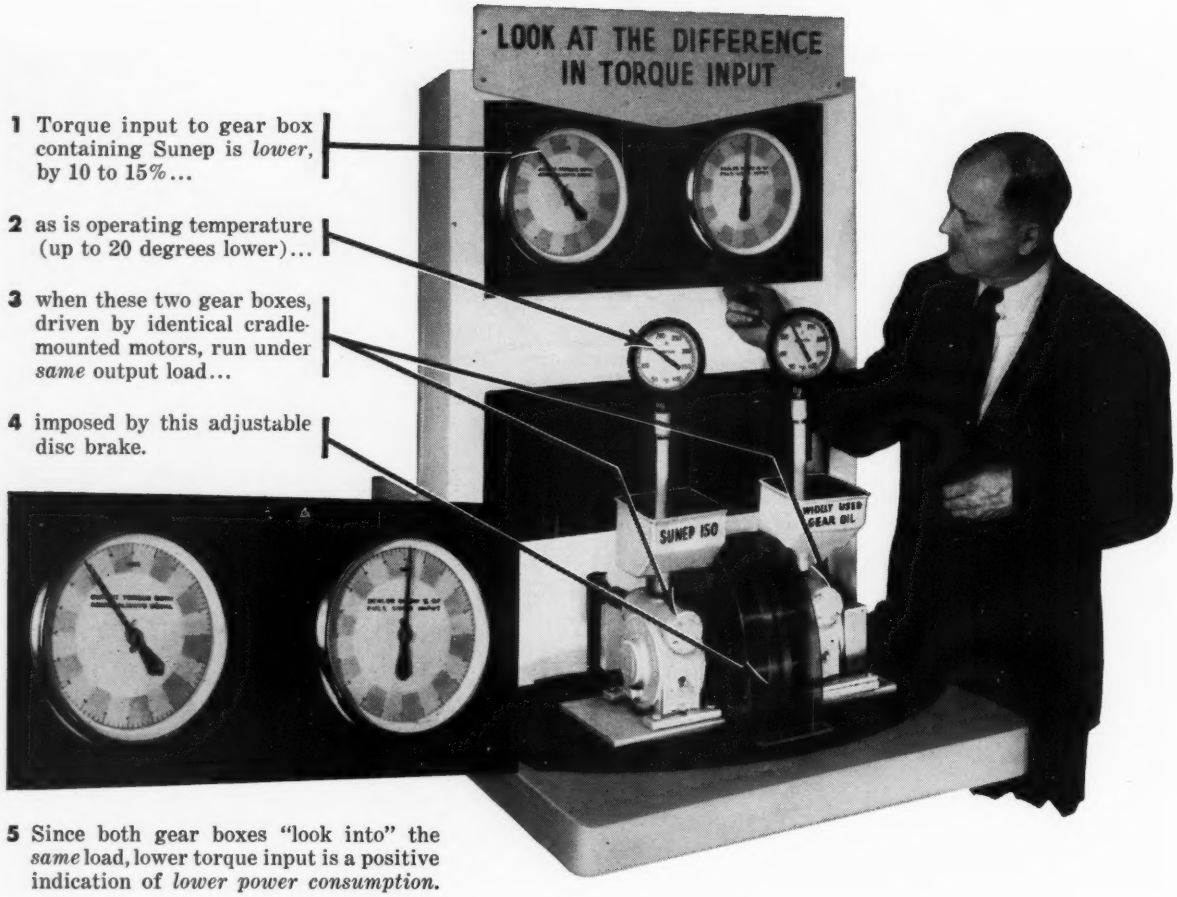
ACHESON COLLOIDS COMPANY

Port Huron, Michigan...also Acheson Colloids, Ltd., London, England

ACHESON COLLOIDAL DISPERSIONS:

Graphite · Molybdenum Disulfide · Zinc Oxide · Mica and other solids

Offices in: Boston · Chicago · Cleveland · Dayton · Detroit · Los Angeles Milwaukee · Philadelphia · New York · Pittsburgh · Rochester · St. Louis · Toronto



1 Torque input to gear box containing Sunep is *lower*, by 10 to 15%...

2 as is operating temperature (up to 20 degrees lower)...

3 when these two gear boxes, driven by identical cradle-mounted motors, run under *same* output load...

4 imposed by this adjustable disc brake.

5 Since both gear boxes "look into" the *same* load, lower torque input is a positive indication of *lower power consumption.*

This test rig proves...

SUNEP CUTS POWER CONSUMPTION, REDUCES OPERATING TEMPERATURES

TIME AND AGAIN, under equal operating conditions, Sunep® gear lubricant has demonstrated its superiority over competitive oils. Sunep is a high-quality, extreme-pressure lubricant that is also recommended for screws and heavily loaded bearings.

In addition to extreme-pressure characteristics, Sunep has the ability to combat rust and corrosion. All additives are compatible and do not drop out during use or prolonged storage. These advantages add up to savings in money and equipment for you.

For complete information about Sunep oils, call your Sun representative or write to SUN OIL COMPANY, Philadelphia 3, Pa., Dept. LE-5

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY Philadelphia 3, Pa.

IN CANADA: SUN OIL COMPANY LIMITED, TORONTO AND MONTREAL

SUNOCO

©Sun Oil Company

LUBRICATION ENGINEERING

RESEARCH APPLICATION EDUCATION MAINTENANCE

Volume 13, No. 5

May, 1957

The Value of "Know-How"

"Know-how" is something born of experience. The more practical the latter may have been, the more thoroughly will "know-how" be retained by an individual. It is possible, of course, to disseminate information dealing with "know-how." From the do-it-yourself idea to the many technical publications which discuss the beneficial effects of doing things correctly, we have the value of "know-how" drilled into us. According to *Link-Belt News*: "Today more than 2,000 business publications with some 10,000 editorial workers are keeping American savvy flowing into the veins of our economic life."

Those who profit by discussions of the experience of others, and who put these ideas into application (as they may relate to their own work) become more and more valuable to their organizations. Nobody can know it all about any subject, and certainly no technical person can carry all of the knowledge about his research, his machinery, or his products in his head. It is physically impossible for the human head to become a handbook. One can, however, file away a vast amount of knowledge as to *where* to look for the details. Those individuals whose memory is good are often more remarkable for their ability to instantly pin-point the source; others may have to resort to some pet reference file. When carefully indexed the latter can be invaluable as an aid to practical utilization.

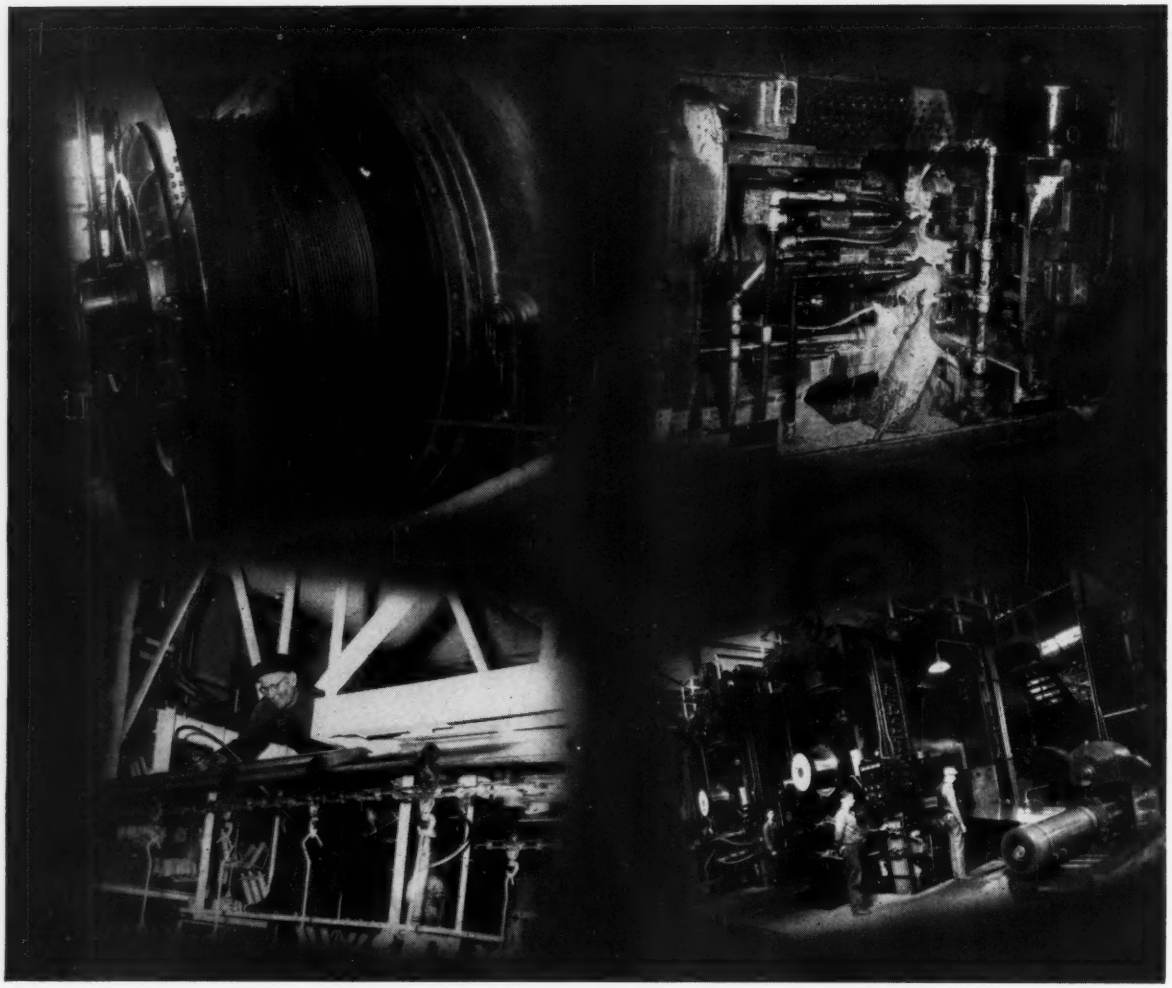
Either way the individual attains the same objective: he knows where to look for information and he knows how to use it. As the years pass some technical people become veritable walking encyclopedias with respect to their particular work. Then they retire. An inanimate file can be passed on to a successor; the mental "know-how" as related to practical usage, however, goes with the retiree.

This is not intended as a dissertation on the merits of memory, filing systems, study, or technical procedures; it is just to draw attention to the folly of letting this "know-how" go to seed. True, in a few years it may become obsolete, due to advancements in science, engineering design, and production methods, if the individual does not keep up-to-date with progress. Meanwhile, however, while his "know-how" is still fresh let's use it. One may ask: How?

The simplest way would be to encourage the technical retiree to take up secondary school teaching. Normally, a certain percentage of the graduates of such schools go on to the technical colleges to study science, chemistry, engineering production or management. Statistics tell us of the shortage of secondary school science and chemistry teachers. The retiree from any technical organization can help to alleviate this shortage if he will consider that he would be doing a service to these students, himself and his community by looking into the prospects of teaching responsibilities.

Young prospective technical people are usually serious minded. They realize the value of the fundamentals of mathematics, physics, and chemistry. They appreciate, however, that these fundamentals must be tempered with practical application to be most useful. Association with the oldster who has developed this "know-how" will be invaluable to them when they go out to develop their own.

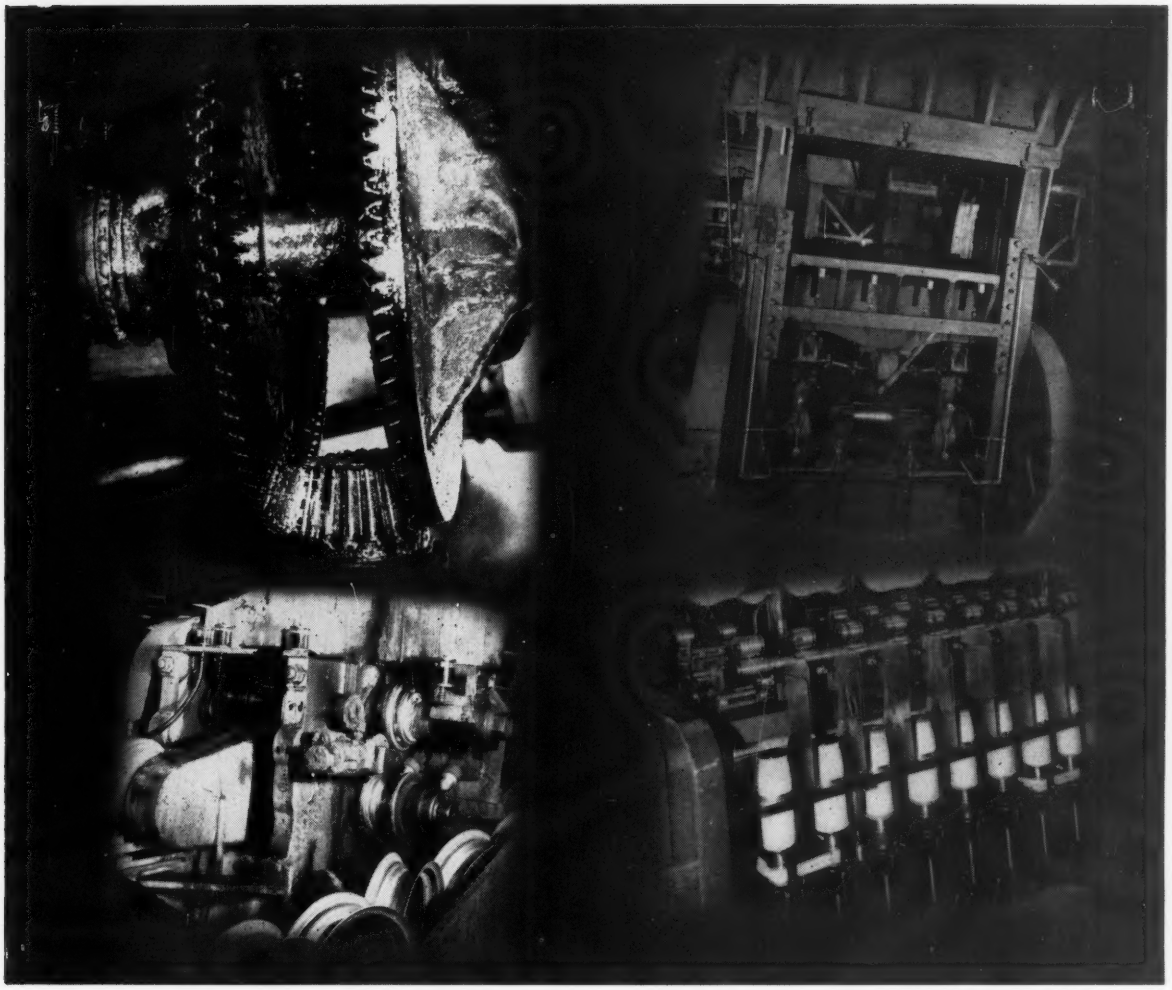
A. F. Brewer
Consulting Editor



MODERN LUBRICATION

Need a pumpable lubricant with high cohesion—a grease that won't melt—a grease that can't be knocked off gears—a lubricant that protects well above 500°F.? Houghton has them, and many more cost-cutting special lubricants just as amazing.

Chances are there's more than one place in your plant where a Houghton "specialized" lubricant can help make your equipment more productive, reduce maintenance and cut costs. Whether in central lubricating systems, open gears, or any other lubrication "problem spot", Houghton can prescribe the right lubricant to do the job.



PROBLEMS: a job for a specialist

IT WON'T MELT *Cosmolube* is a multi-purpose grease that resists heat, water and cold. It has exceptional film strength. Heavy loads will not change its composition. It can be used with any conventional greasing equipment. Requires few applications, little attention even under heaviest service.

SPRAYS ON—STAYS ON *Tenac* is a unique grease for open gears and cables. It sprays on cold, then sets tight. It won't shed, chip, or flake off. The longer it's under a load, the tighter it hangs on. Resists moisture and high gear speeds that no other grease can.

IT WON'T DRIP *Sta-Put* oils and greases do just what their name implies—they "stay put". These specially compounded lubricants provide maximum adhesion and cohesion without latex or other non-lubricating additives.

FOR 300°F. UP Three types of *Hi-Temp* oils cover temperatures up to 1,000°F. Here's ideal, clean, dependable lubrication that keeps wear to a minimum under the most difficult high temperature conditions. Get full information about Houghton's complete line of lubricants by writing E.F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

. . . products of

E. F. HOUGHTON & CO.

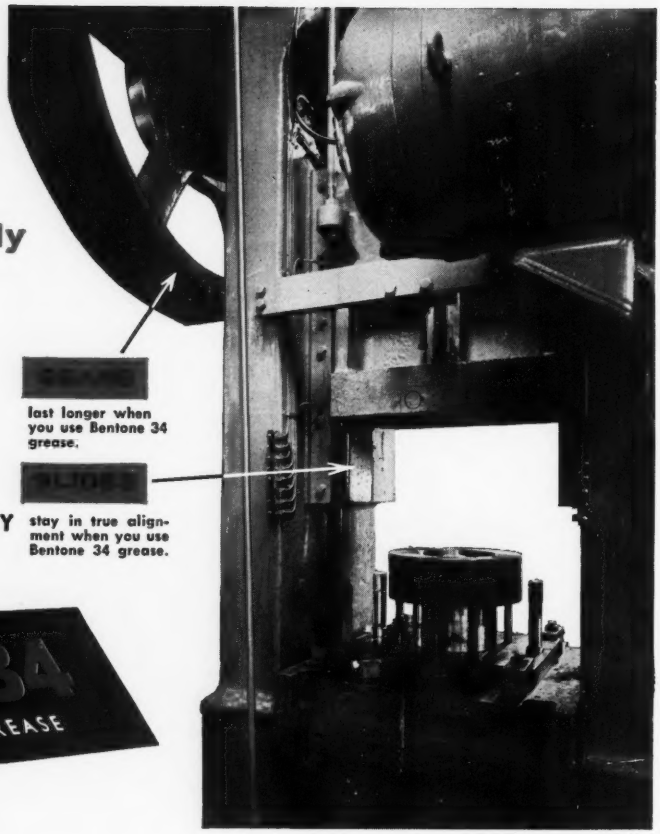
PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

Bentone* 34 Based Grease

Takes Shock Load Easily on 160 TON Press

Heavy duty presses run fair and true under high pressures and shock loads when moving parts are lubricated with greases compounded with Bentone* 34. The F. Hohlfelder Co., Cleveland, Ohio, found by test the most economical, best-lasting grease is one compounded using Bentone 34.



last longer when you use Bentone 34 grease.

stay in true alignment when you use Bentone 34 grease.

Dutch Boy * TRADEMARKS REGISTERED

NATIONAL LEAD COMPANY
BAROID DIVISION
P. O. Box 1675
Houston 1, Texas

BENTONE* 34
FOR MULTI-PURPOSE GREASE

5635

BENTONE* 34 Grease Manufacturers and Distributors

THE ACME REFINING CO., Cleveland, Ohio
ADAM COOKS SONS, INC., Linden, N. J.
ALEMITE DIV., STEWART-WARNER CORP., Chicago, Ill.
ALLUBE CORP., Glendale, Calif.
THE AMERICAN LUBRICANTS CO., Dayton, Ohio
ARKANSAS FUEL OIL CORP., Shreveport, La.
BATTENFELD GREASE & OIL CORP., Kansas City, Mo.
BATTENFELD GREASE & OIL CORP. OF CALIFORNIA, Compton, Calif.
BATTENFELD GREASE & OIL CORP. OF NEW YORK, North Tonawanda, N. Y.
BEL-RAY CO., INC., Madison, N. J.
BOBBISH INDUSTRIAL PRODUCTS CO., Dearborn, Mich.
THE BROOKS OIL CO., Pittsburgh, Pa.
CASCADE PETROLEUM CO., Denver, Colo.
CATO OIL AND GREASE CO., Okla. City, Okla.
CONSUMERS COOPERATIVE ASSOCIATION, Kansas City, Mo.
CRAWFORD EMULSIONS, Pittsburgh, Pa.
DENS-OIL LUBRICANT CO., Kansas City, Mo.
JAMES W. DOYLE CORP., Detroit, Mich.
FISKE BROTHERS REFINING CO., Newark, N. J.
FISKE BROTHERS REFINING CO., Toledo, Ohio
THE FRANKLIN OIL AND GAS CO., Bedford, O.
GEORGIA-CAROLINA OIL CO., Macon, Georgia
GLOBE GREASE & MFG. CO., Los Angeles, Calif.
GOPLERUD LUBRICANTS CO., Mason City, Iowa
GREDAG, INC., Niagara Falls, N. Y.
HI-WAY REFINERIES, LTD., Regina, Sask., Canada
THE HODSON CORP., Chicago, Ill.
THE HODSON CORP. (QUEBEC), INC., Three Rivers, Quebec, Canada
E. F. HOUGHTON & CO., Philadelphia, Pa.
ILLICO INDEPENDENT OIL CO., Lincoln, Ill.
INTER-STATE OIL CO., Kansas City, Kansas
KEYSTONE LUBRICATING CO., Philadelphia, Pa.
LUBRICATION CO. OF AMERICA, Los Angeles, Calif.
MacMILLAN OIL CO. OF ALLENTOWN, Allentown, Pa.
MAGIE BROTHERS, INC., Chicago, Ill.
MAGNUS CHEMICAL CO., Garwood, N. J.
MANITOBA CO-OPERATIVE WHOLESALE LTD., Winnipeg, Man., Canada
METALCOTE OIL CO., St. Paul, Minn.
MID-STATES LUBRICANTS, Kansas City, Mo.
MIDWEST OIL CO., Minneapolis, Minn.
THE OHIO GREASE COMPANY, Loudonville, O.
OIL-KRAFT, INC., Cincinnati, O.
OIL DISTRIBUTORS OF PHILADELPHIA, Philadelphia, Pa.
ONYX INTERNATIONAL, Jersey City, N. J.
PANTHER OIL & GREASE MFG. CO., Fort Worth, Texas
PANTHER OIL & GREASE MFG. CO. OF CANADA, Toronto, Ontario, Canada
PENN-CREST OIL & GREASE CORP., Long Island City, N. Y.
PENN PRODUCTS CO., DuBois, Pa.
PHOENIX OIL COMPANY, Augusta, Ga.
A. B. PLATING SUPPLY CO., Milwaukee, Wisc.
PRAIRIE STATES OIL & GREASE CO., Danville, Ill.
PRECISION BEARING & TRANSMISSION CO., Omaha, Nebr.
RILEY BROS., INC., Burlington, Iowa
THE SAHARA OIL CO., DuQuoin, Ill.
SASKATCHEWAN FEDERATED COOP. LTD., Regina, Sask., Canada
ADOLF SCHMIDS ERBEN S. A., Bern, Switzerland
SERVICE LUBRICANTS, INC., Chicago, Ill.
L. SONNEBORN SONS, INC., New York, N. Y.
SOUTHWEST GREASE & OIL CO., INC., Wichita, Kan.
SOUTHWESTERN PETROLEUM CO., Fort Worth, Texas
SPECIALTY PRODUCTS CO., Jersey City, N. J.
SUNLAND REFINING CORP., Fresno, Calif.
SYRACUSE FIRE BRICK SUPPLY, Syracuse, N. Y.
THREE RIVERS REFINERY, Three Rivers, Tex.
TIDE WATER ASSOCIATED OIL CO., N. Y. C.
TIONA PETROLEUM CO., Philadelphia, Pa.
TOPSALL LUBRICANTS, INC., Kenmore, N. Y.
TOWER OIL CO., Chicago, Ill.
TRANSMISSION EQUIPMENT CO., Pittsburgh, Pa.
TRI-STATE PETROLEUM CO., Philadelphia, Pa.
UNITED COOPERATIVES, INC., Alliance, Ohio
UNITED PETROLEUM CORPORATION, Omaha, Nebraska
UNIVERSAL AVIATION SUPPLY, Wichita, Kan.
G. C. WAKEFIELD & CO., LTD., Toronto, Ontario, Canada
THE WARREN REFINING AND CHEMICAL CO., Cleveland, Ohio
THE WAVERLY OIL WORKS CO., Pittsburgh, Pa.
WESTLAND OIL CO., Minot, N. D.

***T.M. Reg.**

BENTONE·34®

Personals

W. S. Carpenter, III

M. J. McCaughey

E. I. duPont deNemours & Co., Inc., Wilmington, Delaware, has announced the appointment of **W. S. Carpenter, III,** as Director of Sales—Petroleum Chemicals Div., succeeding **D. H. Conklin** who becomes Managing Director of duPont Company (United Kingdom), Ltd. Other personnel changes in the Division resulting from the promotions include: **A. R. Mullis,** as Assistant Director of Sales; **E. G. Bennett,** as Eastern Regional Manager; **D. W. Frison,** as Manager—Central Region; **C. D. Towery,** as Manager — Mid-Continent Region; **R. C. W. Jones,** as Sales Service Manager; and **H. C. Thompson,** as Sales Promotion Manager.

Acheson Colloids Co., Port Huron, Michigan, has appointed **Apco Industries Ltd.,** Toronto, Canada, as distributor of 'dag' dispersions for the Provinces of Ontario and Quebec.

R. L. Leslie (Treasurer of the ASLE Detroit Section), Vickers Inc., has accepted the Chairmanship of the ASLE Hydraulics Committee.

The first presentation of two wards (made available by the American Society for Testing Materials) to be given annually for "outstanding service to standardization and to standardization literature," has been made posthumously to **Dr. Dickson Reck,** Editor of the new book "National Standards in a Modern Economy," by the Standards Engineers Society, Camden, New Jersey.

M. J. McCaughey has been appointed Regional Sales Manager of the Tuthill Pump Co., Chicago, Illinois. He will have charge of the company's sales organization in Wisconsin, northern Illinois, southern Iowa, Minnesota, and eastern Missouri; his headquarters will be in Chicago.

Austin Laboratories (Austin, Texas) of Jefferson Chemical Co., Inc., has announced the formation of two new sections: the Engineering Services Section, with **H. F. Sturgis** as Supervisor; and the Administrative Services Section, with **N. J. Delahoussaye** as Supervisor.

Obituary: **A. T. McDonald** (ASLE Los Angeles Section), Hughes Tool Co., Culver City, Calif., March 16, 1957.

Book Reviews

"ASTM Standards on Petroleum Products & Lubricants (With Related Information)," American Society for Testing Materials, 1916 Race St., Phila. 3, Pa., 1957; 1096 pages, price $7.50.

This special compilation prepared by the ASTM Committee D-2 includes tentative and standard methods of test, specifications, definitions of terms, and classifications of petroleum products and lubricants, with related information including the Report of Committee D-2 on Petroleum Products & Lubricants and proposed methods of test.

Published annually since 1927, the present edition includes 180 standards, 48 of which are new or revised since the previous edition. Some of the new standards are Methods of Test for: Tetraethyllead in Gasoline (D-526), Evaporation Loss of Lubricating Greases & Oils (D-972), Mercaptan Sulfur in Jet Fuels (Color-Indicator Method, D-1219; Amperometric Method, D-1323), and Analysis of Calcium & Barium Petroleum Sulfonates (D-1216).

Among the new tentatives are five methods for calibration of tanks (D-1406 thru D-1410), and Tentative Methods of Test for: Emulsion Characteristics of Steam Turbine Oils (D-1401), Effect of Copper on the Oxidation Rate of Grease (D-1402), Estimation of Heat of Combustion of Liquid Petroleum Products (D-1405), and many others.

The compilation is a valuable aid to chemists and technologists in the petroleum industry. It is also useful for purchasing agents, scientists, and engineers in the automotive, aircraft, railway, and other industries.

"Encyclopedia of Chemical Technology," Editors-in-Chief: Drs. R. E. Kirk & D. F. Othmer, of Polytechnic Institute of Brooklyn; Interscience Publishers, Inc., 250 Fifth Ave., New York City; 15 volumes, 13,805 pages, price $375.00.

This enormous publishing project which has been 13 years in the making, has resulted in a 15-volume book consisting of 13,805 pages of text and a comprehensive

(Continued on p. 296)

the 500 plus molecular weight
sodium petroleum sulfonate

Fully Refined • Maximum Rust Prevention • High Activity • Uniform Quality

*Sherosope-T**

Now available in greater volume to compounders of rust preventives...

Tank Cars or Drums
in carload and less than carload quantities

Bulk deliveries from Gretna, La., and Trainer, Pa. Drum stocks available in principal areas. Write for technical information and samples to address below.

A greatly augmented source of sodium, calcium, barium, and ammonium sulfonates

Immediate benefit to you of Bryton's enlarged capacity is the increased availability of Sherosope-T. In addition to Sherosope-T, Bryton* can profitably and promptly supply you with oil-soluble sulfonates for many other industrial uses. These are prepared as sodium, calcium, barium, and ammonium salts. Sodium sulfonates are offered to you in a wide range of molecular weights. Consequently, you are permitted much greater latitude in selection and utilization.

Whatever your particular requirements in sulfonates, it always pays to take it up with the Bryton representative.

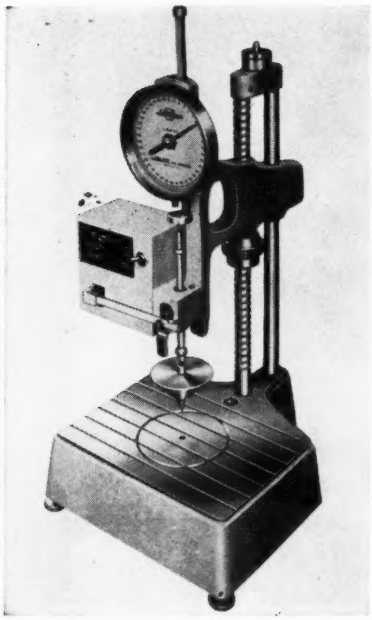
BRYTON CHEMICAL DIVISION Dept. L-5, 1270 Sixth Avenue New York 20, N. Y.

Specific sulfonates for industry

*Trademark

©1957, Continental Oil Company

New Products



Penetrometer

A new *Penetrometer* with built-in automatic electric timer has been announced that features a preset 5-second cycle cam, with reset switch for zero start. The automatic timer eliminates operator error in timing, and is especially desirable when testing light greases with micro and semi-micro cones.

The *Labline Penetrometer* incorporates such features as: (1) 63 mm. penetration, suitable for use with the new Standard Oil of Indiana magnesium cone; (2) 5" dial; (3) dual upright guide posts; (4) quick removable plunger — about 2 seconds; (5) single knob control for head, etc. All castings are aluminum. *Write for Bulletin 4100T, Labline Inc., 3070 W. Grand Ave., Chicago 22, Illinois.*

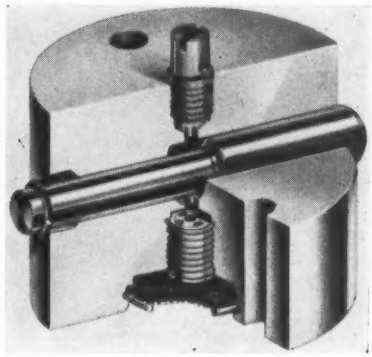
Four-Way Selector Valve

A new four-way selector valve has been introduced for accurate control of liquid flow to multiple-spray manifolds or feed lines. Three outlet connections are provided, and liquid flow through any one or any combination of these outlets is obtained by setting of the control lever. Selection of setting is made with the valve in "Off" position. Positions are indexed for automatic exact positioning of control lever. Valve is opened merely by raising lever handle. If use of less than three outlets is desired, adjustment is made by capping unused valve outlets. The unit is identified as the *TeeValve* and is supplied in choice of ¼", ⅜", and ½" NPT outlet connections. *For complete information, write: Spraying Systems Co., 3201 Randolph St., Bellwood, Illinois.*

Gravity-Feed Oilers

Newest addition to the Company's line of industrial oilers is the *Kwik-Flush* gravity-feed model which eliminates "dry starts" of machinery that has been shut down overnight, weekends, etc. A special reservoir built into the oiler automatically floods the bearing with a fixed amount (approx. ⅛ oz.) of lubricant the instant the oiler valve is opened. Following the flushing cycle, oiler functions in normal manner, feeding lubricant drop by drop at any required rate and again stores up oil for the next flushing cycle while the machine is idle.

Oil flushing after shutdown periods is especially desirable with (1) vertical shafts, where oil drain-off is especially pronounced, and (2) high-speed spindles where full lubrication is required the instant the machine is started. Additional applications include all types of bearings where considerable weight, strains, and pulling loads are present, or where very high accuracy is to be maintained. The oilers are available in 10-oz., 1-pint, 1-quart, and 2½-quart capacities, with either heat-resisting Pyrex or shatterproof Lucite reservoirs, and with manual or electric solenoid shut-off valves. *Write for Bulletin No. 38, Trico Fuse Mfg. Co., 2948 N. 5th St., Milwaukee 12, Wisconsin.*



Piston-Type Oil Pump

Continuous lubrication of a bearing or series of bearings is provided by a new piston pump that has only one moving part. Described as a rotating pump with an oscillating piston, the new unit consists of a cylindrical housing, about 3" in diameter, containing a horizontal stepped piston. It is designed primarily for lubrication of machines with a vertical drive shaft, and is attached directly to the bottom of such shaft. The pump is mounted on the shaft so that it rotates in a fixed eccentric race in a sump, and the ends of the piston, extending beyond the diameter of the housing, ride against the eccentric race. The resulting oscillating action of the piston draws oil into the pump and feeds it under pressure into the bore of the drive shaft and thence to the bearings. *For more information, write: Bijur Lubricating Corp., 151 W. Passaic St., Rochelle Park, New Jersey.*

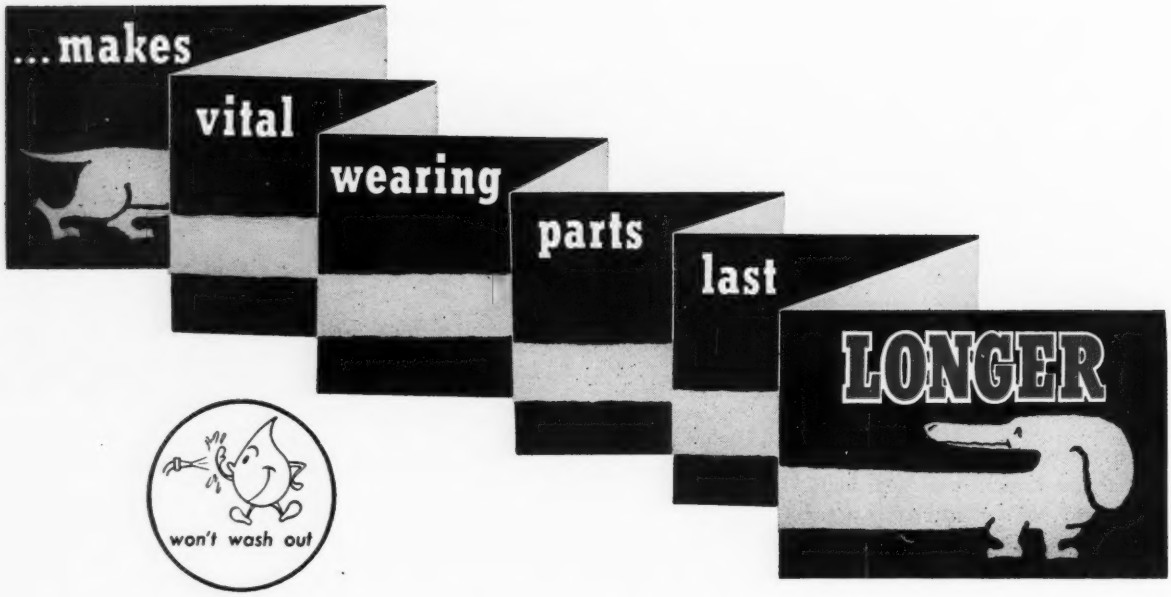
O-Ring Lubrication

O-Lube, a new material that extends the service life of synthetic rubber o-rings, is applied to both the o-ring and the metal surfaces over which the o-ring must slide. The material is especially recommended for low-pressure pneumatic and vacuum systems.

(Continued on p. 294)

Lithium-Base Multi-Purpose

INLUCITE 21...



Because INLUCITE 21 *stays put* in the presence of water . . . because it won't squeeze out or melt out under the most severe conditions of temperature and load, INLUCITE 21 outlasts every specialized grease it replaces in wheel bearings, water pumps, universal joints, springs, shackles, and other grease-lubricated bearings. A trial will convince you. Write for full details.

INTERNATIONAL LUBRICANT CORP.

NEW ORLEANS, LOUISIANA

Manufacturers of Quality Lubricants • AVIATION • INDUSTRIAL • AUTOMOTIVE • MARINE

With Research Comes Quality, With Quality Comes Leadership

ASLE News Notebook

Compiled by
R. D. McCormick

Retiring President's Address Annual Meeting Banquet E. R. Booser

"Mr. Toastmaster, members of the American Society of Lubrication Engineers, and guests.

"We all owe a vote of thanks to the Detroit Section, our National Program Committee, and all of those associated with this splendid banquet tonight and our fine Annual Meeting. The attendance, the enthusiasm, the information distributed here to us at our meeting speaks well for the future of your Society.

"The past year has brought the successful completion of a number of your Society projects. A system of Area Representatives has been established to improve communications for each of you with everyone else in the Society. Your *Lubrication Engineering* magazine now comes to you monthly. The number of you working on Technical Committees has more than doubled in the past two years. Our Lubrication Conference last October at Atlantic City with the ASME was by far the biggest ever. With a 67° ocean, 75° air, and beautiful sunshine, the only complaint I heard was that almost no one brought their swim suits.

"Our membership has grown, and half of you here at the banquet tonight would represent the growth in our membership over the last year.

"Local Sections have had outstanding programs. At each of the last five meetings I had a chance to visit in the past two months, an over-flow crowd was on hand. Two weeks ago, I heard by telephone that the Boston Section had overrun the main dining room in the M. I. T. Faculty Club with some 140 members and guests present. My informant thought he was at the wrong place when he got to the dining room and started looking through smaller rooms to find the meeting.

Retiring president, E. R. Booser addresses the Annual Business Meeting in Detroit, April 15, 1957.

"We have five new local Sections —one at Duluth, one in the Schenectady-Albany-Troy area in New York state, one in Columbus, the Intermountain Section in Utah, and the Puget Sound Section in Washington. Work is actively under way in five other places to start new local Sections, and we hope that there may be other new members present from other areas at our next Annual Meeting.

"The enthusiasm each of you reflected in lubrication work in personal contacts I had with you during the past year emphasized the 'family' label on our Society. You took me to your places of work—in the Mesaubi iron range in Minnesota, your fine petroleum lubrication laboratories, to the B-52 plant at Seattle, one of our country's most modern steel plants—and as a measure of the diversity involved, at the Universal Movie Studio lot at Hollywood, I was taken to lunch at the table next to the Gabor sisters.

"What have been the results of your lubrication engineering spirit? We have seen some spectacular ones during the past year. New bearings and lubricants which allowed a nonstop jet aircraft flight around the world. Research in water lubrication has led to the continued success of the Nautilus atomic submarine, and plans for a completely atomic navy. Lubrication success in rockets has led us closer to having earth satellites.

"But the greatest success we have had has been in keeping the wheels of our American industry moving—and moving more smoothly. Central lubrication systems, better multi-purpose oils and greases, more roller bearings and new lubricants on our railroads, new bearing designs for gas turbines going to industry, improved lubricants for electric motors to help us in our homes and at work, new concepts of lubrication in our automobiles—these all attest to the success and importance of our lubrication engineering activities.

"These kinds of successes, the warm personal contacts that we have

had, the ever brighter future which there appears for you as lubrication engineers and for your Society—all of these things have made my job as your President during the past year a most enjoyable one. With full confidence in your continued success and in the outstanding efforts and guidance which have always been provided by your Board of Directors and your Officers, I now pass on the presidency of your Society to a most enthusiastic leader. I am pleased to present the gavel of the ASLE for the promising year ahead to your President-elect, Dr. John McLean."

Presidential Acceptance Address
J. O. McLean

"It is with deepest humility that I stand before you tonight to accept this honor you have accorded me.

"Our ASLE is a great Society — great because of the basic need for its existence in the first place; secondly and more important, because of the outstanding caliber of the men who founded it, and those who have guided it through its formative stages to the position it now holds as leader in the field of lubrication. I am indeed proud to be a part of this organization as it embarks upon the thirteenth year of its existence.

"Following the example set by my predecessors, I should like to spend a few moments to outline very briefly some of the more important matters with which we will be concerned this coming year.

"The policies of the past year or two will be continued and amplified where possible. I believe that we must always strive to increase our membership if we are to continue to develop. Jim Hopkinson believed this and established a very effective membership program, which unfortunately his health would not permit him to carry out as actively as he normally would have. Dick Booser continued and added to the program, and there will be considerable effort devoted to it this coming year. As our prestige continues to increase, it should, up to a point at least, become easier to obtain not only a large number of members, but also members of the quality we need. We must have active, interested members. We want as many of you as possible to participate in Society affairs.

"Recently, the importance of the position of regional vice-president in the organization was brought into proper focus. A system of area representatives serving under the Regional Vice-Presidents was established. Many of you have already felt the impact of this change. The activity of this group will be stepped up even more this year.

"I feel that very close liaison must be maintained between National and the Section. We need you as members and as Sections, and will do everything in our power to strengthen the bond. We need active Sections. Remember too, that the more you put into the Society, the greater your enrichment. You should take advantage of the Vice-Presidents and their area representatives at your local meetings to ask them questions about your National office and its functions. More and more of this sort of information will be published in *Lubrication Engineering* for your benefit.

President-elect John O. McLean speaks to some of the 1500 members and guests that attended the recent Annual Meeting in Detroit, Michigan.

"Another phase of our activities which I feel warrants continued and increased interest is the field of liaison between our Society and other engineering organizations. Good progress has been made already, but I would like to see us receiving reports of interest from every meeting of other Societies, through our liasion representatives. Recently, for example, our metalworking committee was invited to cooperate actively with the American Society of Tool Engineers on a project involving metal stamping lubricants. This sort of activity will be encouraged, as we feel it is essential to our Society.

"There has always been a strong member feeling that too great a proportion of our papers and publications is devoted to highly theoretical treatises not easily understood or appreciated by many. I would never attempt in any way to discourage such activities, as they are vitally important. On the other hand, I feel that greater efforts can be made to emphasize and encourage the more practical presentations. Steps have been taken in this direction and it will receive attention this year. At this very meeting two sources of such material have been developed.

"Another activity discussed during the past year, which I feel is of great value to our Society, is that of sponsored research projects.

"Realizing that ideas and dreams of today are realities of tomorrow, it is of the utmost importance that our Society do everything in its power to provide conditions permitting not only germination of ideas, but a suitable environment for complete fruition of these ideas.

"We have prepared, ready for presentation to your Board of Directors tomorrow, a resolution asking that an ASLE research fund be established. This fund will be used to initiate and carry out research work of a suitable nature. I sincerely hope this fund is established as I believe it will be another milepost along the road of accomplishments that have put our Society where it is today. This step should be of the greatest value in permitting us to carry out work of vital importance to Industry.

"During the coming year I intend to visit as many Sections as possible—preferably all. I feel that whenever a National Officer can visit a Section, both National and the Section gain immeasurably.

"In conclusion, I would like to assure you that the Officers you have selected for the coming year solemnly pledge to do everything within their capabilities to serve you faithfully, and to advance by every means possible the broad aims of the Society. With the caliber of the men advising the President, I don't see how we can fail."

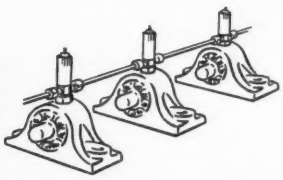
Design for

Automatic Lubrication From One Central Point

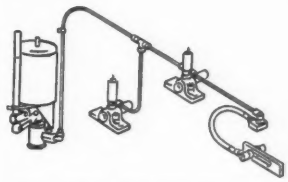
with an ALEMITE Accumatic® System

FASTER . . . FOOLPROOF . . . LESS COSTLY!

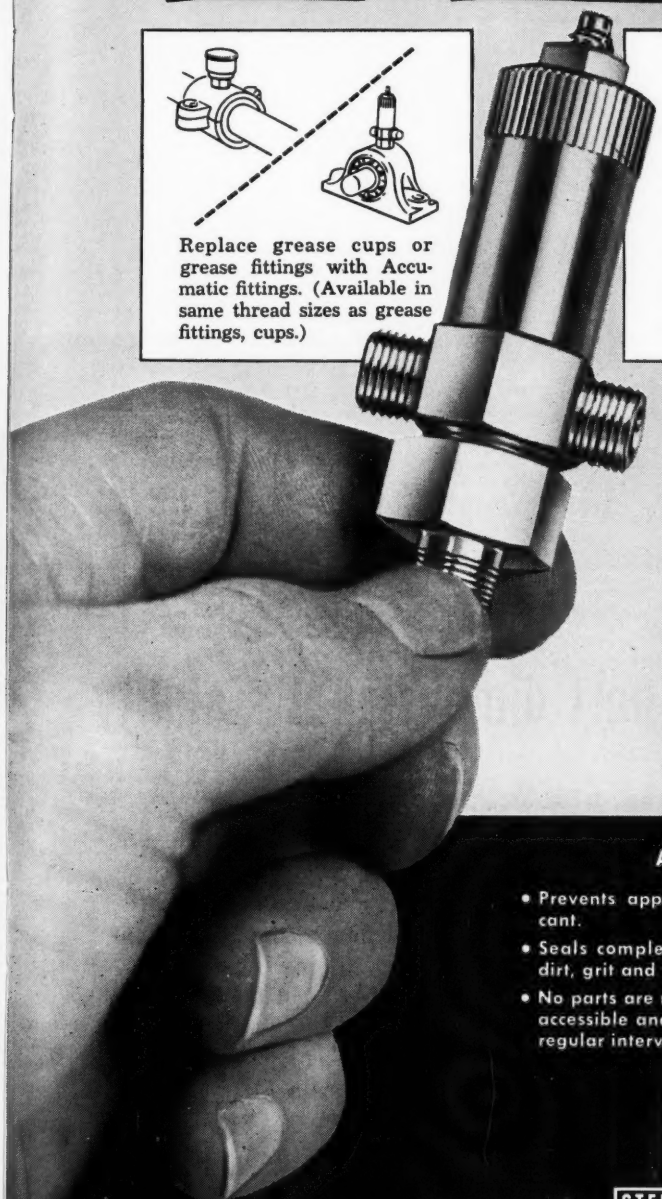
Replace grease cups or grease fittings with Accumatic fittings. (Available in same thread sizes as grease fittings, cups.)



Connect Accumatic fittings with copper tubing. (Alemite has tubing, clips and accessories for easy installation.)



Connect sliding, rotary or oscillating parts into tubing system. (Flexible hose and swivels for moving parts.)

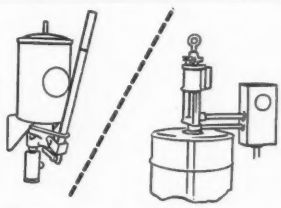


Type 1 Accumatic Valves

For fluid oil or light grease. In range of sizes, delivering from .005 to .100 cu. in. of lubricant. Various shapes: Tees, straight-thru, inserts, angles. Spring pressure provides gradual feed. Adjustable or fixed output. System serves up to 400 bearings. Manual or automatic operation available.

Factory-tested—field-proved!

Grueling field tests show no appreciable variation in the amount of lubricant discharged after 73,312 lubrication cycles—equal to *122 years of twice-a-day service!*



Provide central pump to supply lubricant to system. (Ordinary hand pump or fully automatic barrel pump.)

ALEMITE ACCUMATIC ADVANTAGES!

- Prevents application of wrong lubricant.
- Seals completely against damaging dirt, grit and water.
- No parts are neglected—lubricates inaccessible and dangerous bearings at regular intervals.
- Eliminates product spoilage due to over-lubrication.
- Eliminates point-by-point lubrication methods—services all bearings in one operation.
- Delivers *exact* amount of lubricant to bearing.

ALEMITE
REG. U. S. PAT. OFF.

A Division of STEWART-WARNER CORPORATION

STEWART SW WARNER

FREE! Alemite Accumatic Catalog

Alemite, Dept. DD-57
1850 Diversey Parkway, Chicago 14, Illinois
Please send me my free copy of the complete Accumatic Catalog.

Name .....

Company .....

Address .....

City ..... Zone ..... State .....

Airplane fuel pump rotor molded of a Moly-nylon compound for better dimensional stability and wear resistance than plain nylon can give.
Photo courtesy Polymer Corp.

Moly-Sulfide gives this nylon part dimensional stability

Moly-Sulfide is making the use of plastic and rubber parts possible where they were once impractical

Design engineers can make wider use of many plastic and rubber materials when Moly-Sulfide is added to these compounds as a solid filler. In nylon, dimensional stability, resistance to wear and cold flow are improved, thermal conductivity is increased and surface friction is lowered.

A case in point is the fuel pump rotor shown here. Heat distortion and hygroscopic tendencies of conventional nylon made it impossible to hold strict tolerances. The problem was solved by using a nylon molding compound containing Moly-Sulfide.

Natural and synthetic rubber show improved anti-seize and surface friction properties, thus increasing the life and efficiency of dynamic rubber parts. When used in phenolic laminates, improved high temperature frictional properties are realized.

Further possibilities of Moly-Sulfide are being studied by a number of manufacturers. For more information on this interesting compound, write for Bulletin Lu-12, "Moly-Sulfide as a Filler", Climax Molybdenum Company, Dept. 38, 500 Fifth Avenue, New York 36, N. Y.

CLIMAX MOLYBDENUM

Use the Moly Key to better plastics and rubber

- Improved dimensional stability
- Increased cold flow resistance
- Improved anti-seize properties
- Better wear resistance
- Lower surface friction
- Increased thermal conductivity

Section News

BOSTON, March meeting. Election of Officers (see ASLE Directory), followed by a paper entitled "Setting Up a Lubrication Program," by C. H. Parks, The Bullard Co. Mr. Parks outlined a program for establishing an organized system of plant lubrication, showing the advantages in lower maintenance cost, more efficient machine usage, and longer tool life. One-hundred-plus students of the Section's 1957 "Course in Lubrication for Industry" were guests. (Submitted by E. G. Jackson, Chrmn.)

CHICAGO, March. J. R. McCoy, Indiana Commercial Filters Corp., presented a paper entitled "Filtration of Fuels & Lubricants Used in Industrial Engines," which included a discussion of the various factors involved in filtration that apply to all types of engines. (Submitted by E. W. Drummond, Sec'y-Treas.)

DETROIT, January. Past Chairmen's Night, featuring a paper entitled "Molybdenum Disulfide as a Lubricant — Its Benefits & Limitations," by A. Lewis, The Alpha Molykote Corp. (Submitted by E. S. Kelly, Publicity Chrmn.)

DULUTH/IRON RANGE, March. A. L. Hartley, The Cincinnati Milling Machine Co., presented a paper entitled "The Advantages of a Planned Lubrication Program." (Submitted by C. D. Johnson, Sec'y.)

LOS ANGELES, April. J. L. Kent, Editorial Bureau, Consolidated Electrodynamics Corp., presented a paper entitled "The Keys to Technical Writing Improvement." (Submitted by R. Wheeler, Program Chrmn.)

MILWAUKEE, March. Panel on "Conveyor & Chain Lubrication," featuring R. Wickman (Hotpoint Inc.) as Moderator, with M. Moore (Lincoln Equipment Co.), G. E. Radosevich (American Motors Corp.), R. Cassidy (Filmite Oil Co.), and C. Chavez (Chavez-Flame Co.) as Panelists, followed by a film entitled "The Way of Automobile Lubrication." (Submitted by R. K. Johnson, Sec'y.)

N. CALIFORNIA, April. J. B. Accinelli, Shell Development Co., presented a paper entitled "Grease Lubrication of Ultra-High-Speed Rolling Contact Bearings." Mr. Accinelli discussed the problems associated with grease lubrication of 20 and 25 mm. ball bearings operating in the speed range from 40,000 to 60,000 rpm., and described the effect of various grease and mechanical factors on bearing performance. (Submitted by G. H. Hommer, Sec'y.)

PHILADELPHIA, March. Election of Officers (see ASLE Directory), followed by a paper entitled "Modern Industrial Lubricating Greases," by J. W. Johnson, The Atlantic Refining Co. (Submitted by F. L. Heist, Sec'y.)

TWIN CITIES, March. A. L. Hartley, The Cincinnati Milling Machine Co., presented a paper entitled "Advantages of a Planned Lubrication Program." (Submitted by C. H. Sweet, Sec'y.)

WHEELING, February. R. M. Thurston, Ethyl Corp., presented a paper entitled "Gasoline for Our Automobiles."

March. A "Stump the Experts" Session, featuring J. D. Lykins (Wheeling Steel Corp.) as Moderator, with E. J. Gesdorf (The Farval Corp.), K. D. Reed (Dravo Corp.), and J. C. VanGundy (The Texas Co.) as Panelists. (Submitted by S. J. Litten, Sec'y-Treas.)

YOUNGSTOWN, January. W. J. Varetoni, Cities Service Oil Co., presented a paper entitled "Development of Compressor Lubricants."

February. "What Effect the Type of Base Has on the Thermal & Shear Stability of a Grease," by W. A. Magie, Magie Bros. Oil Co. (Submitted by W. E. McGaffney, Sec'y.)

Coming Events

MAY 16-17, American Society of Mechanical Engineers (Wood Industries Conference), Robert E. Lee Hotel, Winston-Salem, N. C.

16-17, Conference on Mechanisms, Purdue Univ., W. Lafayette, Ind.

16-17, National Industrial Conference Board (General Session), Waldorf-Astoria Hotel, New York City.

16-18, American Institute of Industrial Engineers (Annual National Conference & Convention), Statler Hotel, New York City.

16-18, New York State Society of Professional Engineers (Annual Meeting & Engineering Industries Exposition), Statler Hotel, New York City.

16-18, Society of Naval Architects & Marine Engineers (Spring Meeting), Lafayette Hotel, Long Beach, Calif.

19-23, American Society of Mechanical Engineers (Oil & Gas Power Conference), Kentucky Hotel, Louisville, Ky.

20-21, American Institute of Electrical Engineers (Domestic Appliances Conference), Detroit, Mich.

20-21, Society of American Military Engineers (37th Annual Meeting), Washington, D. C.

20-23, American Society of Mechanical Engineers (2nd Design Conference & Design Engineering Show), Coliseum, New York City.

22-24, American Institute of Chemists (Annual Meeting), Sheraton-Mayflower Hotel, Akron, Ohio.

23-25, California Society of Professional Engineers (Annual Convention), Hotel De Anza, San Jose, Calif.

24-25, Pennsylvania Society of Professional Engineers (Convention & Annual Meeting), Hotel Lawrence, Erie, Pa.

27-29, American Institute of Electrical Engineers (American Power Conference), Sherman Hotel, Chicago, Ill.

JUNE 2-7, Society of Automotive Engineers (Summer Meeting), Chalfonte-Haddon Hall, Atlantic City, N. J.

3-5, American Society of Refrig-

(Continued on p. 296)

MOLYKOTE®

CHECKS "STICK-SLIP" ON A GRAND SCALE

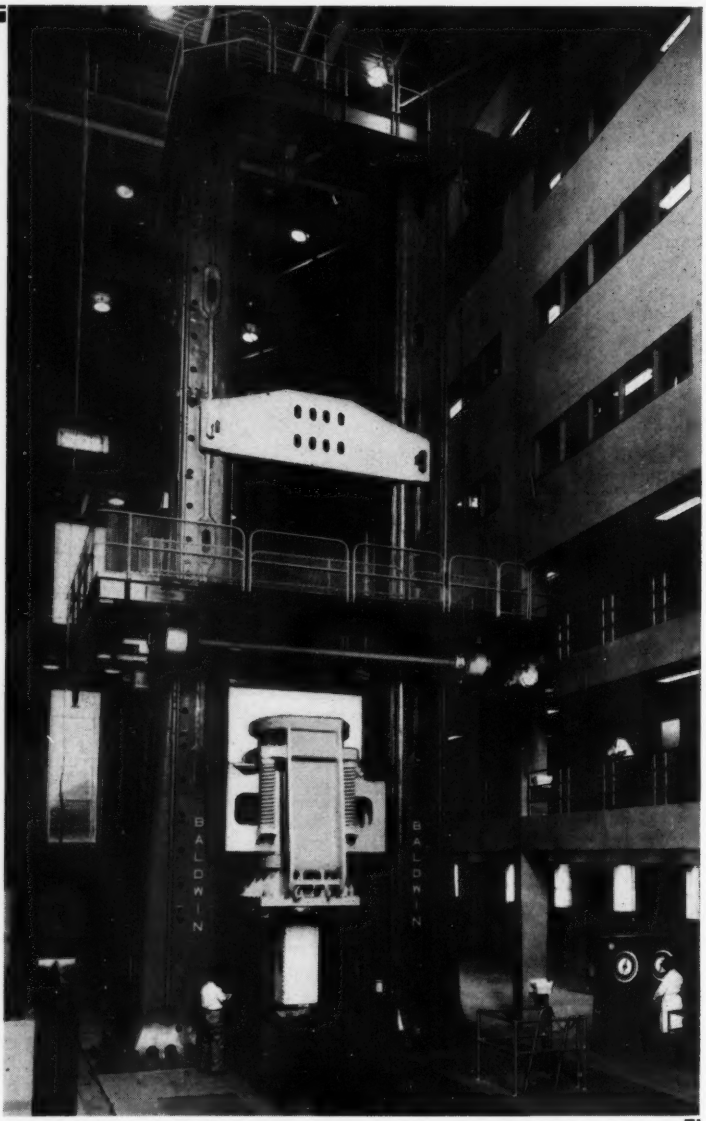
When engineers of Baldwin-Lima-Hamilton Corporation designed and built this mammoth 5,000,000 pound universal testing machine for Lehigh University, they realized from years of experience that extreme testing pressures could cause destructive "stick-slip" action in the test specimen grips and the loading screws.

That is why MOLYKOTE Lubricant was generously applied to both the grips and the screws before the first trial specimen was broken in this giant universal tester.

Baldwin engineers, as well as engineers throughout industry, have come to depend upon MOLYKOTE Lubricant in extreme pressure applications.

MOLYKOTE is manufactured from the purest molybdenum disulfide powder available to industry today. It is compounded under laboratory supervision to retain this purity in the manufacturing process and has achieved an enviable reputation for overcoming the toughest lubrication problems in industry.

MOLYKOTE Lubricant is distributed throughout the world, wherever industry faces the obstacles of providing adequate lubrication in extreme pressure and extreme temperature applications.



5,000,000 pound B-T-E Universal Testing Machine installed in Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pa. Built by Baldwin-Lima-Hamilton Corporation, Eddystone, Pa.

If you are not receiving the new LUBRICATON NEWSLETTER, write today on your company letterhead and we will gladly add your name to our mailing list.

The **ALPHA MOLYKOTE** *Corporation*

Main Factories: 65 Harvard Avenue, Stamford, Conn.
71 Arnulfstrasse, Munich 19, Germany

Lube Lines

by A. F. Brewer*

SIMPLIFIED LUBRICATION

Lubrication is something like safety — too often, regrettably, the beneficiary must be sold on the fact that it is a good idea. There is similarity in other respects also: lack of consideration can be costly and painful. To be sure, a machine which is improperly lubricated feels no physical pain, but it does indicate its discomfort by noises quite akin to a suffering human: groaning, squealing, or whining.

In the development of the practice of lubrication and the advancement of machine design, theory indicated a variety of conditions which could affect performance of both machine and lubricant. A "lubricant for every purpose" became a popular slogan, one which is as apropos today as it was when it was first coined. But the idea of simplification has come into the picture. Possibly the age of standardization exerted an influence, but more probably the human element was the predominating factor. It simply was economically impossible to provide storage for a wide variety of lubricating oils and greases on a job involving heavy-duty construction machinery. Furthermore, there was no assurance that the right products were used in the right places. Some operators never would realize the importance of lubrication.

So the petroleum industry studied the practicability of simplified lubrication, weighing the lubrication requirements of mechanisms against the basic lubrication characteristics of certain groups of lubricants. Why use a cup grease for some fittings and a premium grade anti-friction bearing grease for ball or roller bearings on motors or other parts? The extended durability and greater stability of the premium grade product usually offset the slight difference in initial cost per pound. Today the multipurpose grease is the answer.

The opinions of machinery builders also had an influence. With the hundreds of proprietary brands of lubricants to choose from and the personalities involved, so-called manufacturer's recommendations could become so extensive as to confuse rather than create enthusiasm by the prospective user. Then he was tempted to disregard such recommendations in favor of his own ideas which often were swayed by factors having no relation to proper operation of his machinery.

The lubrication charts which are provided by so many machinery builders today, working in cooperation with their lubricant manufacturers, are evidence of the practicability of simplifying and streamlining lubrication recommendations in line with operating conditions and constructional features. The popular idea of protecting the mechanisms more effectually against entry of contaminants or wear-promoting foreign matter also is a factor. For example, it has proved the practicability of reducing the number of lubricants for heavy-duty, outdoor construction and materials handling machinery to six types of products which are available from a wide variety of sources in the petroleum industry. The identity assures of dependability, i.e. heavy-duty engine oil, multipurpose grease, premium-grade hydraulic oil, etc., means just what the names imply: service suitability and dependability, because specific requirements as to additive content, oxidation and rust resistance, and wide-temperature-range adaptability are built into such products at the refinery. In addition, the all-important relation to safety prevails. Guarding of machine parts keeps personnel out of trouble; keeps the protected mechanisms in operation. Both last longer and exert beneficial effect upon production and the annual report of the management.

PALM OIL REPLACEMENT

There has been quite some discussion of palm oil and the development of a suitable replacement for this unique product as a roll lubricant in cold rolling of steel ever since war-time activities some years ago affected the source of this oil. For decades it seemed to be in a class by itself. Although not an ideal material, it enabled cold rolling to be accomplished more satisfactorily, more economically, and with less friction than with any other product. To be sure, its use presented certain disadvantages such as smudging and variation in uniformity, but so did certain other materials which were proposed at the time as war-time substitutes. All this led to extensive research for alternate lubricants.

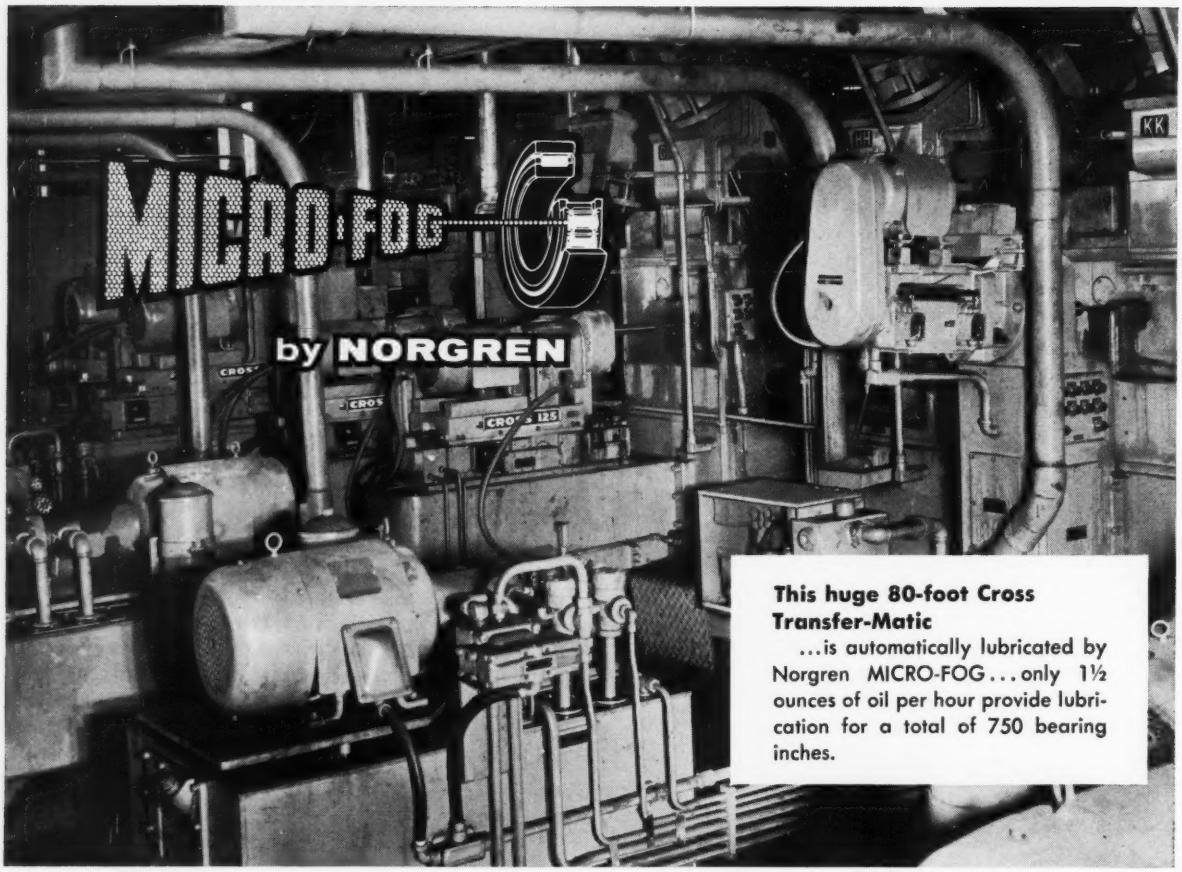
Palm oil as used by the steel industry for cold rolling is more or less of a complex mixture of approximately 10 percent of free fatty acids, with glycerides mostly palmitin and olein. The success which has attended the use of palm oil generally is believed to be due to development of acidity under the prevailing pressures and temperatures of rolling in the presence of water. It is this chemical activity which is considered to be the factor which enables palm oil to develop the degree of lubrication which is so desirable under the operating conditions.

The volume involved is certainly an interesting factor in promoting the research which is being directed towards developing suitable palm oil replacements. Thirty million pounds are conservatively estimated as being the annual requirement. A large percentage of this volume already has been captured: straight mineral oils, compounds of such oils, soluble oil, and a variety of fixed or fatty oils such as sperm oil all are in the picture. Varieties of water-emulsions of these and other materials also are widely used. Sperm oil, for one, apparently has the desired lubricating ability but, here again, lack of uniformity and uncertainty as to source could be against it in case of international restrictions, just as with palm oil. Meanwhile research and plant testing are continually being carried on with reportedly excellent promise. The ultimate objectives are:

- Domestic availability at reasonable cost.
- Uniformity to enable standardization in usage.
- Stability and control of free fatty acid.
- Lubricating ability equal to at least that of palm oil.
- High temperature resistance.
- Production of desired finish.

(Continued on p. 302)

*Consultant, and author of *Basic Lubrication Practice.*



This huge 80-foot Cross Transfer-Matic
...is automatically lubricated by Norgren MICRO-FOG... only 1½ ounces of oil per hour provide lubrication for a total of 750 bearing inches.

AUTOMATIC *Air-Borne* LUBRICATION

for Bearings, Gears, Chains, Cams, Slides, Ways

How Much Oil is REALLY Needed to Lubricate?

The only oil that lubricates is the thin film that separates the metal surfaces. Any additional lubricant is a waste and may even be harmful, causing over-heating due to fluid friction. With intermittent systems, there may be periods when there is not enough oil—and metal wears against metal.

Norgren MICRO-FOG Provides Optimum Lubrication

One MICRO-FOG Lubricator automatically coats all the bearings, gears, chains and other components of a machine with a continuous, protective film of fresh oil. Just the right amount of oil—no more, no less—is continuously applied to provide the most efficient lubrication, reducing wear on machine components and cutting maintenance and replacement costs.

For complete information, call your nearby Norgren Representative listed in your telephone directory—or WRITE FACTORY FOR NEW NO. 800 CATALOG.

TOO MUCH OIL—
Hot bearings due to fluid friction.

TOO LITTLE OIL—
Bearings run hot, wear excessively.

MICRO-FOG Lubrication—
Always just the right amount of fresh oil.

C. A. NORGREN CO.

3434 SOUTH ELATI STREET ..... ENGLEWOOD, COLORADO

Cam & Tappet Test for Lubricants II – Wear Evaluation

A lubricant tester, designed for the study of metal scuff under combined sliding and rolling contact with cyclic variation of load, can be used to evaluate wear before the scuffing occurs. The wear is calculated from Proficorder tracings of the mating surfaces of the cam and tappet test pieces. The wear of cast-iron cams is increased several fold by the addition to the oil of 0.75 percent of an anti-scuff additive, zinc dialkyl dithiophosphate. This increased wear, however, is too small to affect the operation of an automotive valve train adversely. The hardenable iron tappet is less affected by the additive than the cam.

E. H. Loeser, S. B. Twiss & D. M. Teague
Chrysler Corporation
Engrg. Div., Chemical Research
Box 1118
Detroit 31, Michigan

INTRODUCTION

Earlier papers on valve train wear indicate zinc dithiophosphate additive may reduce wear, have no effect, or increase wear. The reasons for the apparent contradiction are probably connected with differences in metallurgy, operating conditions, mechanical design, additive structure, and additive interactions. Bidwell and Vermaire[1] found in their engine tests that two blends containing zinc dithiophosphate obtained from different sources, had no effect on the wear of chill cast-iron tappets which were run on steel cams. Engine tests carried out by Bidwell and Williams[2] showed that a finished oil containing sufficient zinc dithiophosphate to increase the zinc concentration to 0.12 percent, decreased cam and tappet wear of steel tappets on alloy iron cams and of chill cast-iron tappets on steel cams (0.12 percent zinc corresponds to about 1.5% zinc dithiophosphate). Engine tests conducted by Crosthwait, et al[3] indicated increased wear of cast-iron tappets run on hardened cast-iron cams with "E.P. additive Z," and slightly decreased wear with "E.P. additive Y." No information is given about the composition of these additives or the quantities used. Tests made with the G.M. bench tester[4] showed that zinc dithiophosphate reduced the wear of steel tappets when run on alloy cast-iron cams. Zinc dithiophosphate appeared to have no effect on the wear of hardenable iron tappets when run under their mild test condition. It should be noted that cam wear was not measured in most of the investigations, i.e. the wear evaluation was based principally on tappet length measurements. It should also be stated that the exact chemical structure of commercial oil additives is closely guarded, and it is therefore impossible to determine the effect of structure on performance except by synthesizing and determining additive structure in one's own laboratory. In the present paper, this was not done.

It was shown in the first paper of this series[5] that scuffing of hardenable iron tappets run on cast-iron cams was prevented effectively by the use of certain oil additives. In some cases, increased cam wear was obtained concurrently with increased protection from scuff. Since excessive corrosive wear is undesirable, it is necessary to evaluate the amount of wear produced by running with the additive oils.

Wear may be defined, for our purposes, as the gradual and smooth loss of metal between rubbing parts. It does not mean the catastrophic loss of metal such as that which accompanies scuffing.

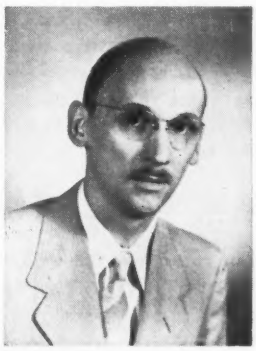
The test apparatus is the one used in the anti-scuff evaluation; the operating conditions were modified in some tests. The object of this paper is to investigate the effect of lubricants and of operating conditions of the test on the wear of the rubbing parts. The study includes an examination of the relationship between wear and scuff.

APPARATUS & MATERIALS

The same apparatus and test specimens described in the preceding paper[5] were employed for the wear studies. The camshaft was motored at 1750 rpm., and the oil temperature maintained at 220° F. The load which the tappets exerted on the cam nose ranged from 220 lbs. at the start of the run to about 950 lbs. at the end of the run.

E. H. Loeser

The test pieces were the standard cast-iron camshafts and spherical-faced hardenable iron tappets described in the previous paper. In all runs, rotation of the tappets



D. M. Teague

S. B. Twiss

This paper was presented at the ASLE 11th Annual Meeting, Pittsburgh, April 4, 1956.

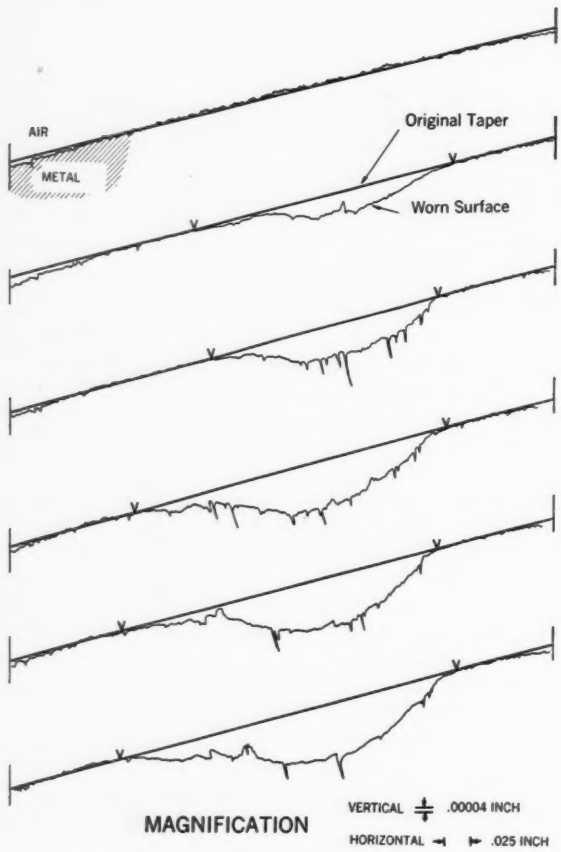


Figure 1. Proficorder tracings across a cam nose, showing progressive wear.

was assured by selection of test pieces for favorable geometry.

Two SAE 10 refined petroleum oils (A and B) were used as base stocks for blending with additive concentrates.

A type BE-1 Proficorder* was used for recording magnified profiles of the cam and tappet test pieces. Pen-drawn charts were obtained which showed the shape, horizontal spacing, and microinch height of the surface irregularities.

Wear Measurements

The wear was calculated from Proficorder tracings of the mating surfaces of the test pieces and from the weight loss of the tappets. Tracings were made across the cam noses parallel to the shaft axis and across the diameter of the tappet face before and after the test pieces were run in the tester. A series of cam tracings in Figure 1 shows clearly that the wear track on the cam becomes deeper and wider with each stage of the run. The Proficorder tracings magnify the cam profile twenty times in the horizontal direction and 2,500 times in the vertical. The taper of the cam is clearly visible.

Cam nose wear was calculated from these tracings. The maximum wear depth is the difference in vertical height between the reference line, which was the contour of the cam before use, and the deepest valley in the wear track. The wear area is the value obtained by measuring the area on the tracing surrounded by the final wear track and the initial reference line; the check marks indicate the width limits of the measurements. A polar planimeter was used to determine this area. The wear volume was calculated as the volume produced by projecting the wear profile through the nose of the cam, as represented schematically in Figure 4A. The tappet face spherical radius, the spherical radius at the cam nose, and the maximum wear depth were used to calculate the wear volume. This is the volume of wear on the nose only. For each type of wear calculation, the values obtained from the tracings were converted into wear in inches, square inches and cubic inches, respectively, by the use of appropriate magnification factors.

Figure 2 shows tracings of a tappet face at progressive stages of a run. The original tracings magnify the tappet profiles twenty times in the horizontal direction and 1,000 times in the vertical. The wear depths and areas of the tappets were obtained in the same manner as the cam wear values. The weight of the tappets before and after use was determined to the closest 0.0002 g. using an underweight tappet as a tare. The tappets were carefully cleaned with benzene and stored in a desiccator before weighing. These weight losses were used to calculate the tappet wear volumes.

The cam and tappet wear depth values have significance in the functioning of a mechanical setup, such as the valve train in an engine, while the wear area and wear volume are closer approximations of the total wear.

RESULTS

Reproducibility of Test Results

The wear values calculated from the Proficorder tracings of the cams and tappets used in a particular run agreed within 10 percent. This agreement between the wear of the test pieces in the four positions of the tester was typical of the wear depth, the wear area, and the wear volume. The agreement between the wear found in duplicate runs was 10 perecent. The reproducibility of tappet wear as measured by loss of weight was about 20 percent. This determination, based on a small difference between two large weights, is probably less precise than the wear

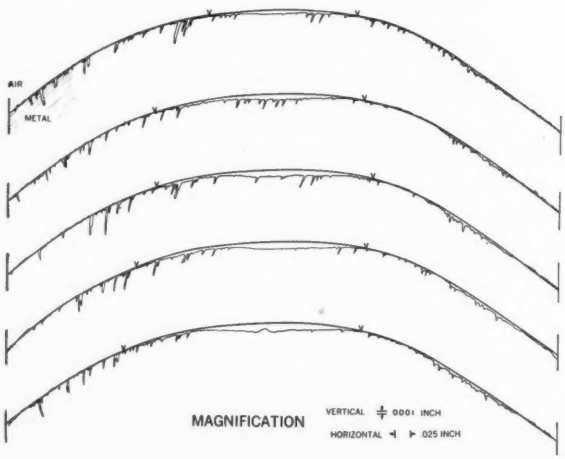


Figure 2. Proficorder tracings across a tappet diameter, showing progressive wear.

*Manufactured by the Physics Apparatus Co. (now the Micrometrical Mfg. Co.) of Ann Arbor, Mich.

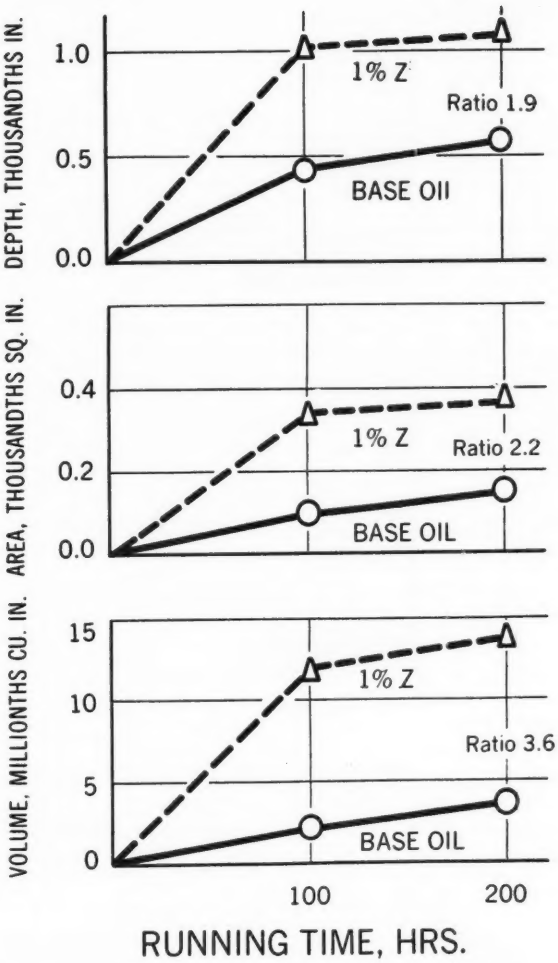


Figure 3. Cam nose wear, as affected by zinc dialkyl dithiophosphate. Test conditions: 300 lb. constant load, base oil B, 220° F.

value calculated from the Proficorder tracings.

Effect of Base Oil on Wear

Cam and tappet wear appeared to be proportional to the running time irrespective of which oil, A or B, was used. No significant difference was found in the amount of wear which occurred in these two oils. It was noted in the previous paper that Oil B, which was less oxidation resistant than Oil A, had a definite anti-scuff effect.

Effect of Additives on Wear

The addition of 1 percent zinc dialkyl dithiophosphate (Z) to base oil B has a distinct effect on cam and tappet wear. Figure 3 illustrates the progressive cam nose wear in terms of maximum wear depth, wear area, and wear volume. In this set of experiments, the spring load was constant at 300 lbs. throughout the test. Proficorder tracings of both cams and tappets were made after 100 hours running, and again after 200 hours. Identical tests were made, with and without the Z oil additive. It is noted that the depth and projected area of cam nose wear is almost doubled by the use of the additive. The wear during the second 100 hours of running is much less than for the initial 100 hours, particularly in the case of the additive oil.

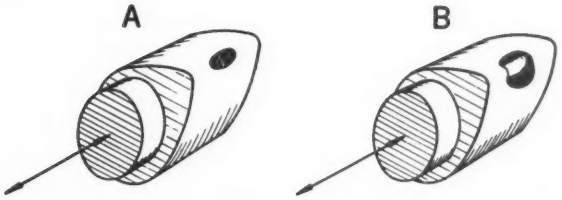


Figure 4. Schematic representations of cam wear. Key: A, projected nose wear; B, approximated total cam wear; arrows indicate axis of camshaft.

Figure 3 also shows the wear directly at the nose in terms of wear volumes which were calculated from the wear profiles projected through the cam nose (See Figure 4A). Here, the effect of the additive on wear appears to be greater as indicated by the ratio of 3.6 between the run with additive and the run with base oil. These volumes make up only a part of the total cam wear, since proficorder tracings indicate appreciable wear on either side of the nose. The wear on the base circle of the cam is negligible. Therefore, the total cam wear is more nearly approximated by the volume of a saddle-shaped ellipsoid formed by the con-

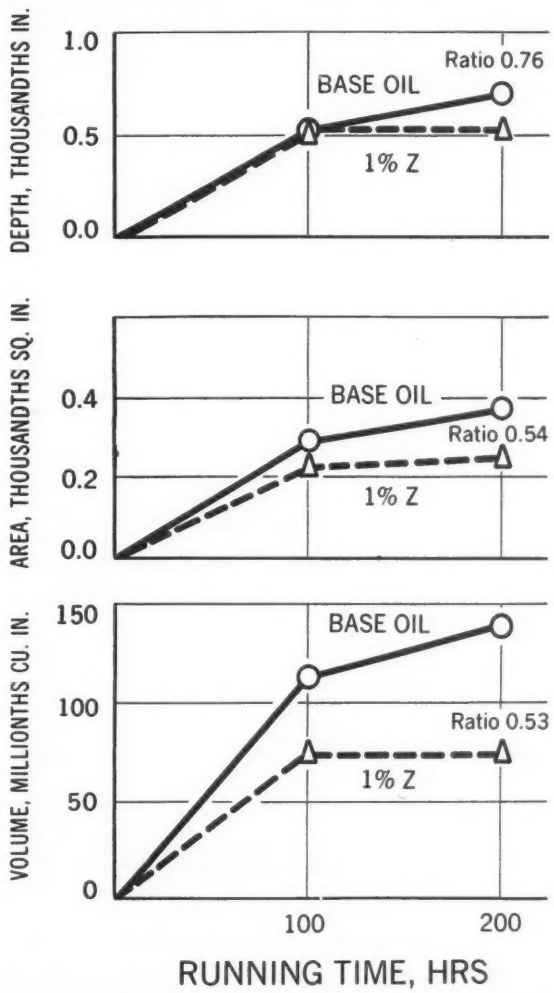


Figure 5. Tappet wear, as affected by zinc dialkyl dithiophosphate. Test conditions: 300 lb. constant load, base oil B, 220° F.

Table I
Cam & Tappet Wear Volume — 200 Hour Test

	Base Oil B	Base Oil B + 1% Z
Cam Wear (millionths cu. in.)	33	96
Tappet Wear (millionths cu. in.)	137	71

tact of the spherical tappet face on the cylindrical cam nose, as represented schematically in Figure 4B. The tappet face radius, the maximum length of the cam wear scar measured in a plane perpendicular to the camshaft axis, and the maximum wear depth were used in this calculation. The calculated total wear volumes, as shown in Table I, are much larger than the calculated cam nose wear volumes. Methods for more accurate evaluation of the total cam wear are being investigated.

In Figure 5, the tappet wear is plotted in terms of maximum wear depth and projected area, as affected by one percent Z. These tappets are the ones associated with the cams shown in Figure 3. Surprisingly enough, the tappet wear is decreased by the use of the Z additive. Since the tappet face has a phosphate coating, the thickness of this coating and appropriate densities of phosphate and iron were considered in calculating the wear volumes. Calculations indicated that the tappet wear in oil containing Z was chiefly composed of the phosphate coating. When run with base oil, both phosphate coating and underlying iron were worn. The wear volumes, calculated from the tappet weight losses taking into consideration the density and thickness of the coating, are plotted in the lower section of Figure 5.

It appears from the calculated total wear volumes shown in Table I that the addition of Z to an oil decreases

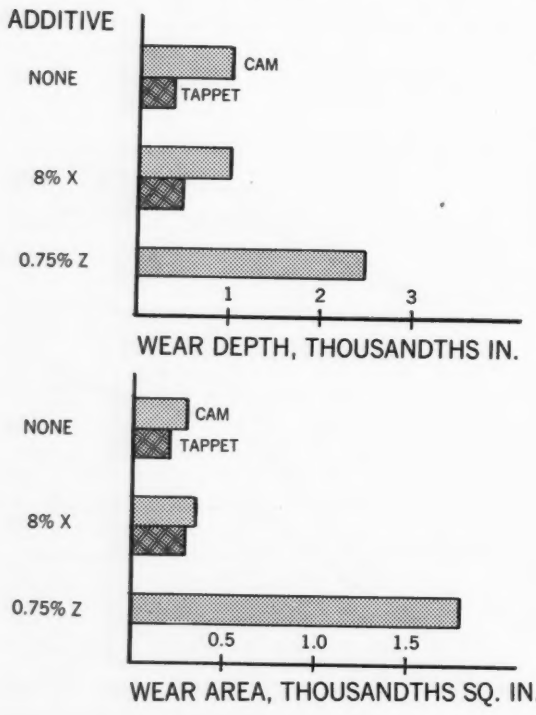


Figure 6. Effects of detergent additive "X" and zinc dialkyl dithiophosphate additive "Z" on cam and tappet wear. Test conditions: 21-hour run-in at 220 lbs., then 100-lb. increments every 3 hours to 950 lbs., base oil A, 220° F.

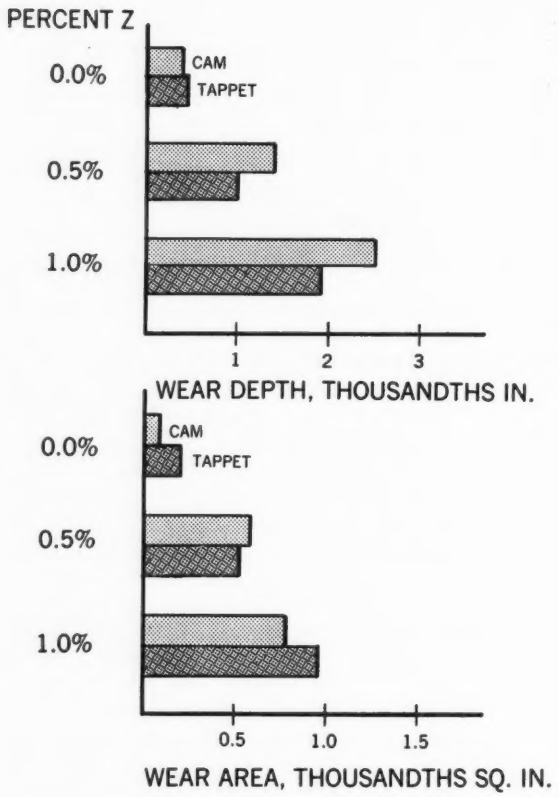


Figure 7. Effect of zinc alkyl dithiophosphate concentration on cam and tappet wear. Test conditions: no run-in, 410-lb. starting load, then 100-lb. increments every 3 hours to 950 lb., base oil B, 220° F.

the tappet wear and increases the cam wear. It may be only coincidental but the sum of the total cam wear volume and tappet wear volume obtained in the additive oil is about the same as the sum of these wear volumes in the base oil.

It will be pointed out subsequently that the ability of Z to decrease tappet wear is not evident at higher loads, where the wear generally remains constant or is increased. At the intermediate load of 300 lbs., the film strength properties of Z evidently decrease wear, and corrosive wear is not important.

Table II is a compilation of the wear ratios shown in Figures 3 and 5 comparing the additive with the base oil. It will be noted that qualitatively the same trends in wear were traced by all of the methods.

In differentiating between the anti-wear properties of oils, the wear depth appeared to be less sensitive than the wear area, while the wear volume was more sensitive than the area. These conclusions were based on the ratios between observed wear with and without 1 percent of zinc dialkyl dithiophosphate. It was assumed that the same accuracy was obtained in all wear evaluations .

Table II
Wear Ratios of Cams & Tappets

	Cam Nose	Tappet
Wear Depth	1.9	0.76
Wear Area	2.2	0.54
Wear Volume	3.6	0.53

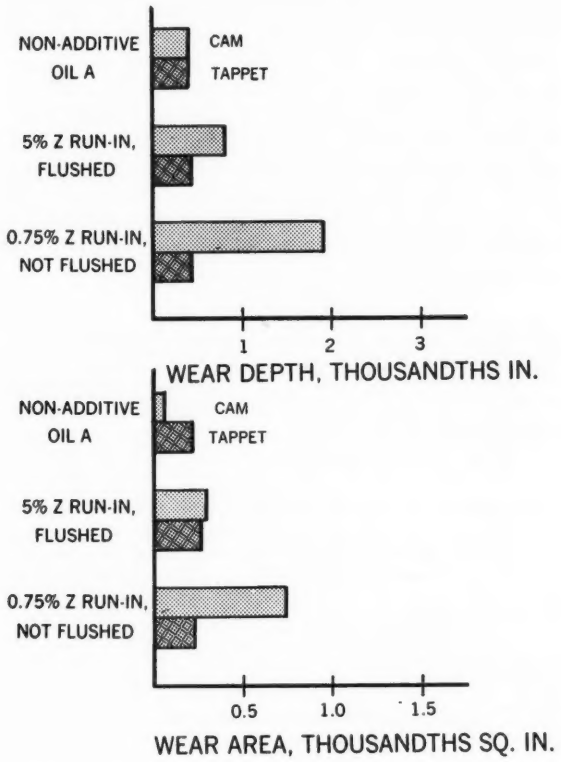


Figure 8. Effect of run-in with oil containing zinc dialkyl dithiophosphate on cam and tappet wear. Test conditions: 1 hour at 410 lb. with run-in oil, drained or flushed as noted, run completed with base oil A, 100-lb. increments every 3 hours to 950 lb., 220° F.

Another series of experiments with a different test procedure was also used to compare the effect of additives on wear. Here the cams and tappets were run-in twenty-one hours at 220 lbs. spring load. The load was then increased in approximately 100 lb. increments every three hours. Wear measurements were made after the final load (950 lbs.) was reached.

The bar graph of Figure 6 shows that the addition of 8 percent of a commercial detergent additive X, containing calcium sulfonate, calcium phenate and barium phenate, to base oil A had no effect on the wear of either cams or tappets. The addition of 0.75 percent of a commercial zinc dialkyl dithiophosphate additive increased the cam wear several fold. Tappet data were not available for this run.

Another series of runs was carried out with various amounts of zinc dialkyl dithiophosphate in Oil B. These runs were made under severe operating conditions, that is, they were started at high loads (410 lbs.) with no run-in, and the load increased in 100 lb. increments. The results given in Figure 7 show an increase in both cam and tappet wear with increase in additive concentration.

Effect of Run-In on Wear

Several runs were made in which the test pieces were run at 410 lbs. load for one hour in an additive-containing oil; this oil was either drained or was completely flushed from the tester; the test was then continued in the base oil A, with increasing load increments as described above. Since a small quantity of an additive or impurity might have an effect on the test results, the apparatus was flushed three times with kerosene between oil changes.

The bar graph of Figure 8 and the Proficorder tracings in Figure 9 show that cam wear was increased by a one-hour run-in in an oil containing 5 percent zinc dialkyl dithiophosphate. This increase in cam wear was not as large as that due to the small amount of additive oil left in the tester after draining the 0.75 percent additive oil. It will be noted that the wear of the phosphate-treated, hardenable iron tappets was about the same in all cases.

DISCUSSION

In general, the wear of the test pieces was proportional to the running time irrespective of the oil used and the rate of wear appeared to moderate as the run progressed (Figures 1, 2, 3, and 5). A commercial detergent additive did not affect the cam and tappet wear. It was shown in the previous paper[5] that this additive gave limited anti-scuff properties to an oil.

The zinc dialkyl dithiophosphate additive increased the wear of cast-iron cams several fold. This was true for a variety of test operating conditions and for both base oils. The wear was proportional to the additive concentration. This suggests that the increased cam wear in oils containing zinc dialkyl dithiophosphate was due to a chemical reaction between the additive and the cam metal. Although the spring loads used in this investigation were higher than those found in present day valve trains, calculations in the previous paper show that the unit Hertz stresses are only moderately higher. As a consequence, the temperatures at the contacting surfaces may have been moderately higher than normal. It is possible that at lower loads and lower temperatures of the mating surfaces, the chemical activity of the zinc dialkyl dithiophosphate would be less than reported here. It must be emphasized, however, that

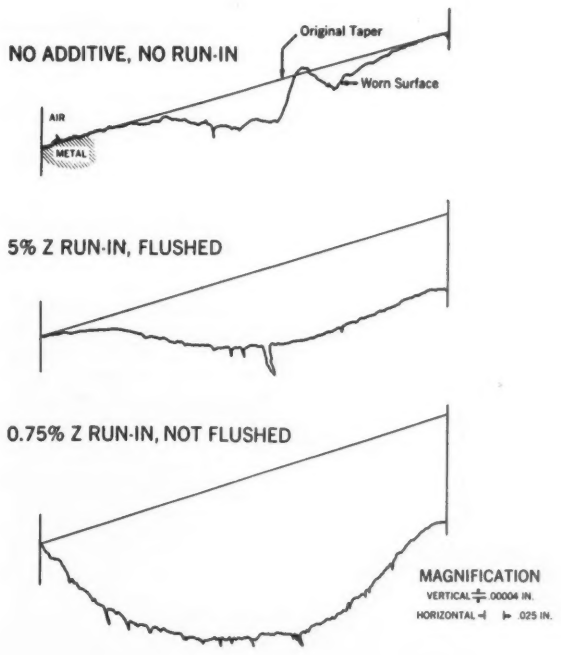


Figure 9. Proficorder tracings of cams showing effect on wear of run-in oils containing zinc dialkyl dithiophosphate. Test conditions: same as Figure 8.

even this increased wear of test pieces in the additive oils is many times too small to cause any malfunction of the valve train of an automobile. There appears to be a connection between this increased cam wear and the anti-scuff properties which this additive gives to an oil. This scuff prevention is in part due to the mating of the cam and tappet surfaces through controlled wear of the surfaces (Figure 9).

A one hour run-in with an oil containing this additive gave some anti-scuff protection even if a non-additive oil was used subsequently. The faster mating of the surfaces during the short run-in, (center of Figure 9) was probably sufficient to produce a beneficial effect. The total wear here was less, because a non-additive oil was used for the remainder of the test, than resulted (bottom of Figure 9) when a lower concentration of Z was present during the entire run.

The phosphate-treated, hardenable iron tappets appeared to be less susceptible than the cast-iron cams to the action of the zinc dialkyl dithiophosphate. In fact, the addition of 1 percent of the additive to Oil B, decreased tappet wear under moderate load (Figure 5). Continuous exposure to high concentrations of this additive at high loads appeared to be required for increased tappet wear.

SUMMARY

It appears from the work presented here that film strength or extreme-pressure additives reduce scuffing tendencies by greater wear of the mating parts in the early stages of running. This increases the area of contact, decreases the unit load, and produces smooth mating surfaces whose contours or profiles are very similar. There is also evidence that even in the absence of rapid wear, film-strength additives can reduce the tendency to scuff, probably by the formation of anti-welding films. Further work, with a wider range of such additives, should be carried out to establish quantitative relationships between wear and scuff prevention and the effect of anti-welding films.

BIBLIOGRAPHY

1. Bidwell, J. B. & P. Vermaire, "Lifters & Lubricants," *S.A.E. Trans., Vol. 63*, 1955, pp. 211-220.
2. Bidwell, J. B. & R. K. Williams, "The New Look in Lubricating Oils," *ibid., Vol. 63*, 1955, pp. 349-361.
3. Crosthwait, R. E., E. A. Martin & J. F. Socolofsky, "Limited Study of Valve-Train Wear," *ibid., Vol. 63*, 1955, pp. 220-221.
4. Etchells, E. B., R. F. Thomson, G. H. Robinson & G. K. Malone, "Interrelationship of Design, Lubrication & Metallurgy in Cam & Tappet Performance," S.A.E. Passenger Car, Body & Materials meeting, Detroit, Mich., March 1-3, 1955.
5. Loeser, E. H., D. M. Teague, P. J. Willson & S. B. Twiss, "Cam & Tappet Test for Lubricants, I — Anti-Scuff Evaluation," *Lubrication Engineering, Vol. 13, No. 4*, 1957, p. 191.

ACKNOWLEDGEMENTS. We wish to express our appreciation to A. Thomson of Physics Research for proficorder measurements, and to J. Rogoff, P. J. Willson & P. R. Basford for mathematical interpretation of the data.

COMMENTARY

G. H. ROBINSON, GENERAL MOTORS CORP.

We wish to compliment Dr. Twiss and his co-authors on two excellent papers. The method used for wear measurement is especially commendable, and we found the Proficorder traces illustrating the mating of the cam and tappet surfaces very enlightening.

From reading, we were unable to discern the difference between test procedures used for scuff tests and those used for wear tests. We wonder if the authors will clarify this point. For example, procedure number 3 of the first paper (scuffing evaluation) appears to be the same as procedure number 4 of the second paper (wear evaluation); i.e., 410 lb. starting load, load increased in 100 lbs. increment every 3 hours. However, in one instance scuffing occurred at 410 lbs. with plain oil B (Figure 4 of the first paper), while in another case with the same oil, a load of 950 lbs. was apparently reached without scuffing (Figure 6 of the second paper).

We agree with the authors' explanation of the increased wear observed with the zinc dialkyl dithiophosphate treated oils on the basis of the chemical reactivity of the additive.

With the test conditions employed, little wear was observed with the plain oil, indicating that conditions for these wear tests were not severe enough to evaluate normally the EP quality of the lubricant. In this situation, the only effect of the zinc dialkyl dithiophosphate should be somewhat greater wear, since the cyclic formation and removal of the resultant phospate film would produce some chemical loss of metal in addition to normal wear; although the wear in either case is slight under the conditions of these tests.

The rating of the two types of lubricants (plain vs. zinc dithiophosphate treated) on the basis of wear would be reversed under conditions severe enough to cause very rapid wear or scuffing with the base oil.

These results emphasize the fact that operating conditions for such bench tests must be carefully controlled, and the data must be examined critically, as the authors have done, to avoid erroneous conclusions.

AUTHORS' CLOSURE

In answer to Mr. Robinson's question about the difference between Test Procedure Number 3 of the anti-scuff evaluation paper and Procedure Number 4 of the wear evaluation paper: there is none. Positions 2 and 4 of the tester were used for scuff evaluation and Positions 1 and 3 for wear evaluation. As was pointed out, Positions 2 and 4 reproducibly failed at a lower load than Positions 1 and 3 (Figure 3, Reference 5). Perhaps we are not entirely justified in using the wear values for the non-additive oil given in the top set of bars of Figure 6, since they were obtained from the only cam and tappet of the eight used in duplicate runs which did not fail before reaching a load of 950 lbs.

Our test conditions, in general, were sufficiently severe to cause scuffing in the non-additive oil. Under severe conditions, it seems that the smooth wear in non-additive oil is less than in one containing zinc dithiophosphate. In fact, it is our belief that the increased wear of zinc dithiophosphate oil leads to better mating and lower unit surface stress. Further work will be required to establish definitely the relative importance of these factors in scuff prevention.

As Mr. Robinson suggests, we have distinguished between normal wear and the extremely rapid wear characteristic of scuffing (catastrophic wear). Apparently, some investigators in this field have not distinguished between smooth wear, occurring prior to scuffing, and catastrophic wear which occurs after the onset of scuffing. With normal wear, zinc dithiophosphate slightly accelerates removal of metal. Under conditions so severe as to produce scuffing with a non-additive oil, wear in this oil is extremely rapid (catastrophic). At comparable loads, oil containing the zinc dithiophosphate additive prevents scuffing and, thus, apparently prevents this excessive, catastrophic wear. We substantiate this observation.

ASLE-ASME 4th Lubrication Conference, October 7-8-9, Toronto

— SYMPOSIUM ON INDUSTRIAL DERMATOSES —
(Part 6 of a Series)

Prevention of Industrial Dermatitis

M. L. Beardslee
Detroit Diesel Engine Div.
General Motors Corp.
13400 W. Outer Dr.
Detroit 28, Michigan

About 2300 years ago Hippocrates pointed out that lead was a poison. Some 300 years later Pliny, the Elder, wrote about the use of animal bladders to prevent breathing in poisonous red mercury sulphide dust. It was not until early in the 19th century that industrial hazards were given any constructive recognition, and then efforts were directed at curative rather than preventive methods of control. It is only within the last 25 to 30 years that real progress has been made toward the use of preventive measures to further industrial hygiene.

Industrial Dermatitis is a serious problem. We, in General Motors, are very conscious of this problem, and it is our aim to reduce Industrial Dermatitis to the absolute minimum. There are many angles to consider, such as climate, personal hygiene, machine cleanliness, use of primary irritants, and the people themselves. People are funny! A little hint of a suspected hazard may lead to immediate illness or needless panic. Therefore, we must be cautious in our approach. Any statements that can be misinterpreted may be used as a means of germinating misinformation.

CLEANLINESS — A "MUST"

Case histories indicate that more Industrial Dermatitis results from the lack of personal cleanliness than from any other contributing cause. Lack of good housekeeping in a plant leads to unsanitary conditions that adversely influences the operator. You just can't say to the operator: "Man, you are filthy; go wash." So the next best thing is to set a good example and provide good facilities for personal hygiene. A popular saying of my first boss was, "The dollar sign is always at the top of the page." Providing facilities, such as are illustrated in the following figures, pays dividends—regardless of cost.

M. L. Beardslee

Clean, well lighted, and ventilated cafeterias as illustrated in Figure 1 make it attractive for men to use the wash-up facilities before they eat.

Clean, roomy locker facilities (Figure 2) make it possible for the men to remove the soil of the day's work before eating or going home. All our modern plants are provided with adequate wash stands, soap, water, and good locker facilities.

In addition, the better equipped plants provide plenty of shower facilities (Figure 3) so that people on particularly dirty jobs can do a thorough clean-up job before leaving their place of employment.

Experience indicates that hand soap must be carefully selected and policed to provide one that is free from abrasive scrubbers that cut the skin, making for easy entrance of infectious bacteria, and also free from harsh alkalis or solvents that defat, leading to skin irritation and cracking (Figure 4).

There was a time when employee education was the prevailing need. Today, we have nearly accomplished that goal and are now faced with a new problem; but maybe not new either, for there is always the careless or shiftless employee who is just naturally dirty.

I am sure that the doctors have adequately covered the fact that certain individuals are naturally susceptible to skin irritants or allergies. Fortunately, these people are very much in the minority, and by assigning selected jobs, they do not create a major problem.

PREVENTIVE MAINTENANCE VERY IMPORTANT

One of the major considerations in selecting a cutting or grinding fluid is the effect on the health and cleanliness of the operator. Legitimate manufacturers of these mate-

Figure 1. A typical clean, well lighted cafeteria.

This paper was presented at the ASLE 10th Annual Meeting, Chicago, April 13, 1955.

Figure 2. Locker room facilities.

Figure 3. Close-up of shower facilities.

rials recognize the need for avoiding the use of toxic and harmful ingredients in their "cook book" recipe. Many of these good coolants are spoiled by poor control and preventive maintenance in the plant, and many operators get oil boils because they are not made to recognize the need for using plenty of good soap and water.

Figure 5 shows a machine, in which there has been a premium-quality water-soluble cutting fluid, which has been in use for several years. Recently this machine suddenly developed a sticky, dirty condition, particularly around the tool post and on the ways. This is the result of lubricating oil leaking into the cutting solution, coating the ways, tools, and chucks with a cast iron dust oil mixture, resulting in a sludge formation that was a breeding ground for bacteria. Such a condition is detrimental to men and machines. This led to early rancidity in the solution, but in spite of this condition, the operator was free from any dermatitis. This operator made good use of our sanitary facilities, otherwise he might have been a victim of oil dermatitis. Needless to say, those seals were replaced immediately.

The "Wee-Beasties" known as bacteria seem to thrive almost everywhere. Those that cause the stink in soluble solutions thrive best in the absence of air. Therefore, it is a good rule to keep the sump of the machine clean, free from chips and sludge, so that they will have no breeding place. Bactericides in carefully controlled dosage do aid in the control of rancidity. Over-dosing can and frequently does cause serious skin rash, leading to loss of time.

Oil drippings from leaking seals or over-greasing tend to coat the top of the solution, as shown in Figure 6, blanketing off the air so that aeration is reduced to a point where the little beasties go to work and create a stink. Note the gobs of grease on the surface.

A little blast of air on the surface of the sump revealed the clean solution under the oily "gunk" (Figure 7).

Over-greasing provides oil blobs which accumulate on chips and settle in corners and out of the way places in the sump of the machine, forming a perfect hiding place for the bacteria that deteriorate coolants. Therefore, it is a good second rule to prevent oil leaks and over-greasing. This is double-barreled economy, since in addition to saving the cutting fluid, it saves on lubricants and lubricating time. In addition, it prevents the loss of efficiency of the cutting or grinding solution due to the contaminating and diluting effect of the lube oils. Dirt and filth due to careless lubrication around the operator's station is transferred to the operator's clothes and person. This, in turn, may plug the pores of the skin leading to oil boils, loss of efficiency, and other disturbing results.

Infrequently we encounter a machine that has become infected to a point where ordinary cleaning methods will not remove the breeding ground of bacteria, particularly in coolant lines and complicated manifolds such as are encountered in most machines. In such cases, we have found

Figure 4. Hand soap has been very carefully selected.

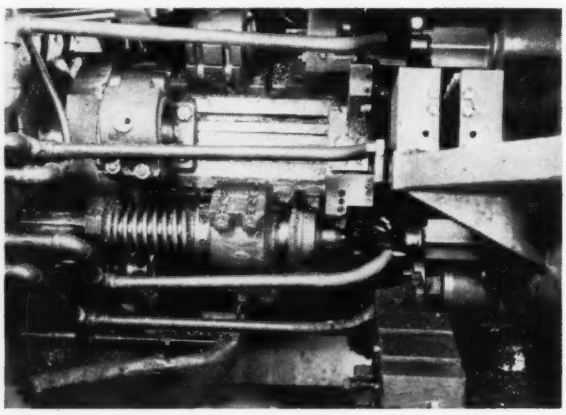


Figure 5. Example of dirty machine caused by leakage of lubricating oil.

Figure 6. Soluble oil emulsions, coated with layer of lubricating oil and grease, provides breeding ground for bacteria.

Figure 7. Notice the clean emulsion under the layer of "gunk."

it necessary to set up immersion electric heaters in the coolant sump, and to provide hot, strong alkali solutions; for example, 4 oz. TSP plus 2 oz. of caustic soda per gallon, which was flushed through the pump and lines, dissolving and removing the sludge formations.

This particular operation is now infrequently used, but the setup has been made available to take care of machines that become chronic offenders. In other cases, such as large grinding operations, an accumulation of hardened grinding sludge is built up in the machine base and hidden places, and has proven to be a breeding ground for bacteria.

A proprietary agent has been added to the grinding coolant, and by continual treatment we were successful in softening and removing these deposits. This requires considerable personal attention, but in the long run has been found much less expensive than a complete teardown and overhaul of the machine which may become necessary as the deposits build up to a point where they interfere with the table operation.

The Safety Director of the General Motors Corporation cited as an example of the effect of dermatitis, two plants in the Corporation: one of which has some 6000 hourly rated employees, 1¾% of whom were treated in the Medical Department for some form of dermatitis during the past year. These are not actually "lost time" cases but medically treated cases wherein the employee continued to work. To arrive at a loss of production figure would be very difficult to determine; because the only loss of time from production would be that incurred during the visit to the Medical Department, or that which may result from transfer to another job until the dermatitis was cleared up. Furthermore, no compensation was paid on these cases. In the majority of cases the Medical Department tries to keep the employee working, if possible, so that the plant doctors can keep them under strict medication in order to clear up the case.

Another group of approximately 2200 production employees had 220 cases of dermatitis reported to the Medical Department. They did, however, have an unusual situation at the plant in which they started a new operation; before they were fully aware of a dermatitis hazard, they had over 100 people affected. However, this was quickly brought under control, and the plant's dermatitis situation is back to normal with 4 or 5 employees per month visiting the Medical Department for treatment of dermatitis.

There are as many specific methods of policing coolants in General Motors as there are individual plants. Each and every one has found that regularly scheduled policing pays dividends in eliminating the breeding grounds for bacteria growth, thereby increasing the coolant life and operating efficiency.

SUMMARY

In conclusion, we might sum up the case for prevention of Industrial Dermatitis as follows:

(1) Provide attractive facilities for good personal hygiene of the operator.

(2) See that the operator provides for frequent changes of clothing to overcome infection from this source.

(3) Provide checked and qualified grinding or cutting fluids which do not contribute to unsanitary or hazardous operating conditions.

(4) Provide good means of machine cleaning on regular operating schedules to eliminate breeding grounds for bacteria.

(5) Eliminate sources of contamination of cutting fluids such as oil leaks and over-greasing.

We might sum it up by saying that the future of industrial hygiene is in policing of materials and process, and through education of people in the ways of better health and hygiene.

It's Toronto in '57

ASLE-ASME 4th Lubrication Conference

October 7-8-9 Royal York Hotel

Summaries of Foreign Papers

"Investigation of Wear & Friction," by A. A. Bartel, E. H. Kadmer, J. Moos & G. R. Schulze, Inst. f. Erdoelforschung, *Schmiertechnik, Vol. 3*, 1956, pp. 184-191.

A test machine is described which permits the evaluation of wear and friction characteristics of lubricating oils under loads varying from 2,500 psi to 62,500 psi and at velocities from about 0.0013 fps to 12.1 fps. The machine consists essentially of a ring in the lower half on which two rollers are mounted 90° apart. These rollers are mounted halfway in the ring so that they cannot move. The journal rests on these two rollers producing at the beginning of the test a true line contact of known dimensions. By a special suspension mechanism, the ring containing the two rollers can be pressed against the journal to provide known loading conditions. A set-up similar to a torquemeter is used to measure the friction coefficient. The change of this friction coefficient is recorded electronically. The amount of wear of the rollers is determined by weighing and correlated to the wear scar diameter which is measured under a metallurgical microscope. Since two rollers are used, each test run (usual duration 3 hours) provides duplicate results. The discoloration of the rubbing surfaces is also noted and correlated with the performance of the oil. Various types of base oils and their corresponding EP versions (additives containing S, Cl, N, or phosphorous and phosphoric acid esters, or thioacid esters, as well as combinations of P, N, Cl and S) as well as motor oils of the multi-viscosity and HD type were examined. The effect of surface finish of the rollers and of various types of pretreatment of the surfaces was also investigated. The reproducibilty of the results was found to be satisfactory. The test results are claimed to correlate closely with the known performance of the lubricants in the field. (*Reviewed by E. O. Forster*)

"Oil Additives & Mechanism of Their Action," Parts 2 & 3, by W. Zajezierski, *Nafta* (Poland), *Vol. 8*, No. 5, 1952, pp. 125-128, & No. 6, pp. 155-159.

These two papers give a general discussion of the following types of additives: pour depressants, V. I. improvers, additives for improving boundary lubrication properties, oxidation inhibitors, detergents, corrosion inhibitors, and anti-foam agents.

POUR DEPRESSANT

The action of "Paraflow" in depressing the pour point is thought to be the inhibition of the crystal growth and also the change in crystal form from needle-like to equiaxial. X-ray study cited by the author shows that pour depressant reduces the size of crystals to 10^{-3} to 10^{-9} cm (*Reviewer's Note: The lower limit of the size of crystal is smaller than atomic dimension*). It is also stated that pour depressants are more effective in the presence of V. I. improvers. The distillate from Baku crude oil of 6° C. natural pour point can be depressed to —10° C. by addition of 1% "Paraflow" and to —25° C. by addition of 5% "Woltol."

V. I. IMPROVERS

The author discussed the effectiveness of polyisobutylenes of various degrees of polymerization: "Exanol" (approximate molecular weight 2500), "Woltol," "Superol U" (7,500), "Superol" (23,000), "Oppanol" (80,000 to 400,000). A V.I. improver consisting of "Exanol" in a mineral oil is known commercially as "Paratone." At 5% concentration, "Paratone" increases the V.I. of naphthenic-base oil from 26 to 111 and the V.I. of paraffinic-base oil from 91 to 124. "Woltol" is about as effective as "Paratone." "Oppanol" is the most effective. The author states that, as a rule, the effectiveness of poly-isobutylenes as V.I. improver increases with their molecular weight. This is explained by the known fact that the resulting mixture of high- and low-viscosity oils has a V.I. higher than the average V.I. of the components — the greater the difference in viscosity of the components, the greater is the increase in the V.I. over the arithmetic mean value.

ADDITIVES FOR IMPROVING BOUNDARY LUBRICATING PROPERTIES

As lubricity improvers, the author mentions the use of vegetable or animal fats and fatty acids whose oxidation products are usually corrosive. Nitriles, ketones, and amides of fatty acids are not only non-corrosive but more stable at high temperatures. For example, nitriles of stearic acid and those of lauric acid are stable at temperatures up to 450° C. Ketones must contain mixed radicals, one aliphatic and the other aromatic. Some of the ketones can also depress the pour point (e.g., the condensation product of chlorinated stearic acid with high-boiling fractions of coal tar). Extreme-pressure additives include lead soaps (soaps of fatty or naphthenic acids), sulfur- and chlorine-containing compounds (products of reacting vegetable oils or animal fats with sulfur or sulfur chloride at 160° C.) and also mixtures of both. The author attributes the extreme-pressure properties of the chlorine-containing additives to the chlorine liberated during severe rubbing.

OXIDATION INHIBITORS

Test results cited by the author indicate that oxidation-resistance of oils with or without oxidation inhibitors is greatest when an optimum amount of sulfuric acid is used in treating the oil. The effectiveness of an oxidation inhibitor depends on the chemical composition of the oil. Phenyl-β-naphthylamine is effective in turbine oils from Artemovsk crude, but has not effect in Surakham paraffinic-base oils. Resins with polycyclic aromatic radicals connected to short alkyl chains in oil reduce the effectiveness of inhibitors of the aminophenol type. *p*-Hydroxy-diphenylamine which is more effective in oils containing less resin (used in concentrations of 0.01%) is considered as one of the best oxidation inhibitors.

DETERGENT

Detergents are classified into the following groups: (1) Metal soaps such as aluminum naphthenate, calcium phenolstearate, etc. (2) Alkyl phenolates of calcium, cobalt, and barium. (3) Reaction product of P_2S_5 and high-molecular hydrocarbons neutralized with potassium hydroxide. (4) Metallic salts of sulfonic acids.

(Continued on p. 300)

The Effects of Nuclear Radiation on Lubricants

A portion of the Air Force effort toward the development of nuclear radiation-resistant lubricants is devoted to an evaluation of the effects of gamma radiation on specification-type lubricants. Data are presented on the effects of gamma radiation on petroleum and synthetic-base hydraulic fluids, lubricants, and engine oils. Many of the materials tested appear to be satisfactory for use after exposure to about 1 x 10^8 roentgens of gamma radiation, the screening dosage used for these studies.

J. A. King & W. L. R. Rice
Wright Air Development Center
Wright-Patterson Air Force Base
Dayton, Ohio

INTRODUCTION

The Materials Laboratory, Wright Air Development Center, is conducting a program to determine the effects of nuclear radiation on aircraft lubricants. The portion of the work reported herein consisted of subjecting specification-type lubricants and hydraulic fluids to gamma radiation. After irradiation, as many specification-type tests as possible were conducted on the limited amounts of sample available.

The irradiations were conducted at ambient temperature in the gamma grid of the Materials Testing Reactor at Arco, Idaho. The flux levels were of the order of 1×10^6 roentgens per hour. Radiation dosages varied for each test sample, but were approximately 1×10^8 roentgens. Since only gamma radiations were used, activation and the resulting residual radioactivity was not a problem in the testing.

Nuclear radiation, regardless of the type, ultimately causes ionization or electronic excitation in organic fluids, with the resultant formation of free radicals and various other products. As a result of irradiation, polymerization or depolymerization takes place. Gas evolution or unsaturation may also result. The effects of such reactions in lubricants are difficult to follow, since the formulated lubricant is a multi-component system and its useability cannot generally be defined by one particular test. Since the lubricants studied in this program were chiefly performance-type lubricants, it was decided to assess damage by running as many pertinent performance specification tests as sample size or time would permit. In each case, it was not possible to run all the definitive tests required to determine the usefulness of a lubricant, but enough information was obtained to give an indication of radiation damage.

MATERIALS

GREASES

Samples of greases were irradiated in sealed canisters at ambient temperature (about 75° F.). Grease types selected included the conventional aircraft greases and various specialty and experimental greases. The specification-type greases tested conformed to one of the following specifications: MIL-G-3278, MIL-L-3545, MIL-L-4343, MIL-G-7187, or MIL-L-7711. Data obtained on the testing of the irradiated greases are presented in Tables I through VII. Certain of the standard grease tests were not conducted, due to lack of sample or excessive test time requirements.

LUBRICANTS

The hydraulic fluids and engine oils were irradiated under conditions similar to those for the grease irradiations. The six fluids studied were subjected to a dosage of approximately 1×10^8 roentgens. These materials included a chlorophenyl silicone hydraulic fluid, a silicate-type hydraulic fluid, and the conventional red oil specification MIL-O-5606 petroleum-based hydraulic fluid. A diester MIL-L-7808 type and two petroleum-based MIL-L-6082 oils were also evaluated. Specification-type tests were used to determine changes in properties as a result of the irradiation. Data are presented in Tables VIII through XI.

DISCUSSION

GREASES

Some comments are in order as to the general trends that seem to take place when greases are subjected to gamma radiation. The dropping point of the grease was not adversely affected. It either increased or remained the same. Pressure changes during bomb oxidation were from 100 to 1000% higher for the irradiated grease than for the control sample. This was probably due to the unsaturation or susceptible fragments produced by gamma irradiation. Copper corrosion resulting from irradiated grease was not peculiar to a particular specification. In the majority of cases, copper corrosion results were not affected. Evaporation loss, oil separation, and low temperature torque remained within reasonable limits in the grease categories covered.

Changes in grease composition were studied using infrared techniques. Greases were analyzed in their compounded state only. Most changes noted were limited to a gain or loss of intensity of a particular band, but were not sufficient to indicate the radiation damage of a grease. Many greases which suffered excessive softening or pressure drop did not give a visible change in the infrared spectra. The quantity of samples prevented separating each grease into its respective components and conducting infrared analysis on each component. By such separation, changes which were undetected in the compounded state may be noted.

The penetration of the greases examined was affected by the irradiation. The general result was a softening of

This paper was presented at the 3rd Annual ASLE-ASME Lubrication Conference, Atlantic City, October 8-10, 1956.

the grease. In some cases, however, hardening was also noted. MIL-G-7187 penetrations were unchanged at 1×10^8 roentgens.

The effect of gamma radiation on penetration and grease structure was studied further by subjecting MLG 9305, an arylurea-thickened silicone grease, to stepwise irradiations from 1×10^6 to 3×10^8r. Data on the effect of irradiation on penetration are given in Table VII. No change in penetration is noted at 1×10^6r. At 3×10^6r and 1×10^7r, penetration increased only slightly. Beyond 1×10^7r, penetration increases rapidly until at 3×10^8r only a soupy mixture remains. Between 3×10^8r and 1×10^9r the grease becomes a rubbery solid. It appears that at some point between the liquid state noted at 3×10^8r and the rubbery solid formed at 1×10^9r the grease penetration decreases, passing through the original penetra-

Table I
Effects of Gamma Radiation on MIL-G-3278 Type Greases

	Dosage (r)	Dropping Point	Penetration Unworked	Penetration Worked	Bomb Oxid. 5 psi max	Bomb Cu Corr. ½ psi max	Evap. Loss (%) 1.5 max	Oil Sep. (%) 5.0 max	Low Temp. Torque 5 sec max	IR Change
	Spec. Req.	Over 325° F.	.....	260-310						.....
Grease A	Control	382	254	258	3.0	0.0	0.57	1.00	1	
	7.59×10^7	380	351	361	25.0	0.0	1.50	2.60	1	No
Grease B	Control	378	264	242	2.5	0.7	0.24	1.25	½	
	7.21×10^7	385	310	324	4.0	Fails	1.06	1.80	2	No
Grease C	Control	385	283	290	0.0	0.0	0.17	0.36	1	
	9.85×10^7	392	343	350	9.0	Fails	1.36	3.90	1	No
Grease D	Control	386	272	273	1.0	0.0	0.73	2.20	1	
	9.54×10^7	393	280	297	15.0	Fails	1.70	2.80	2	No
Grease E	Control	390	273	290	Pass	0.0	0.79	0.34	2	
	8.74×10^7	390	328	350	11.0	4.0	1.26	2.10	3	No
Grease F	Control	366	261	278	Pass	Pass	0.23	4.20	¼	
	6.75×10^7	377	306	343	8.0	Fails	0.96	2.90	1	No
Grease G	Control	360	235	229	Pass	4.0	0.65	1.10	1	
	11.2×10^7	375	269	286	24.0	1.0	1.30	1.10	3½	No
Grease H	Control	354		290	2.0	3.0	1.00	0.37	1	
	9.08×10^7	360	306	324	20.0	Fails	1.64	4.10	2	No
Grease I	Control	340	268	297	Pass	0.0	0.49	0.47	1½	
	9.28×10^7	345	280	347	3.0	Pass	1.97	4.80	1	No
Grease J	Control	340	261	263	3.0	0.0	0.59	4.00*	½	
	7.14×10^7	356	295	305	13.0	Fails	1.19	4.70	1	No
Grease K	Control	355	250	286	Pass	0.0	0.72	0.38	¼	
	8.75×10^7	355	291	320	7.0	2.5	1.24	5.20	3	No
Grease L	Control	362	251	252	2.0	0.0	0.39	0.00	2	
	9.95×10^7	377	273	293	4.0	1.0	1.43	0.60	4	No
Grease M	Control	Over 500	347	357	Pass	Pass	0.16	3.10	2	
	8.60×10^7	Over 500	369	369	6.0	1.0	0.92	1.80	1	No

*48 hr. at 212° F.

Table II
Effects of Gamma Radiation on MIL-L-3545 Type Greases

	Dosage (r)	Dropping Point	Penetration Unworked	Penetration Worked	Corrosion on Copper No Pitting	Bomb Oxidation 10 psi max Press. Drop	IR Change
	Spec. Req.	Over 350° F.	.....	.....			.....
Grease A	Control	472	310	313	Pass	5.0	
	9.36×10^7	480	349	399	Pass	5.0	Yes
Grease B	Control	360	194	237	Pass	0.0	
	8.74×10^7	Over 500	186	275	Pass	2.0	Yes
Grease C	Control	394	272	339	Pass		
	10.2×10^7	408	268	369	Pass	4.0	Yes
Grease D	Control	430	261	290	Pass	3.0	
	9.01×10^7	334	255	263	Pass	1.0	Yes
Grease E	Control	400	242	244	Pass	Pass	
	9.66×10^7	405	307	286	Pass	3.0	No

Table III
Effects of Gamma Radiation on MIL-L-4343 Type Greases

	Dosage (r)	Dropping Point	Penetration Unworked	Penetration Worked	Corr. on Cu No Pitting	Bomb Oxid. 5 psi max	Evap. Loss (%) 2.5 max	Oil Sep. (%) 5.0 max	IR Change
	Spec. Req.	Over 325° F.	.....	260-300					.....
Grease A	Control	406	268	271	Pass	4.5	0.55	0.72	
	10.2×10^7	410	337	350	Pass	8.0	0.85	1.07	No
Grease B	Control	374	244	252	Pass	Pass	0.62	2.06	
	9.55×10^7		Sample Solidified						
Grease C	Control	380	227	267	Fails	0.0	0.36	2.54	
	8.00×10^7	378	224	260			0.39	0.60	No

Table IV
Effects of Gamma Radiation on MIL-G-7187 Type Greases

	Dosage (r)	Dropping Point	Penetration Unworked	Penetration Worked	Corr. on Cu	Bomb Oxid.	Evap. Loss (%)	Oil Sep. (%)	Low Temp. Torque	IR Change
	Spec. Req.	Over 300° F.	.....	265-340	No Pitting	5 psi max	2.0 max	5.0 max	10 sec max	.....
Grease A	Control	302	272	302	Pass	Pass	0.6	3.3	1	No
	10.9×10^7	330	223	305	Pass	4.0	0.8	3.6	1	No
Grease B	Control	287	306	308	Pass	Pass	0.4	6.7	3	No
	7.92×10^7	340	264	300	Pass	8.0	1.0	5.7	1	No

Table V
Effects of Gamma Radiation on MIL-L-7711 Type Greases

Specification	Dosage (r) Requirements	Dropping Point Over 300° F.	Penetration Unworked	Penetration Worked 265-340	Corr. on Copper No Pitting	Bomb Oxid. 5 psi max Pressure Drop	Low Temp. Torque 10 sec max	IR Change .....
Grease A	Control	385	263	264	Pass	2.0		
	7.74×10^7	374	231	267	Pass	4.0	3	No
Grease B	Control	314	306	320	Pass	5.0	3	
	8.91×10^7	325	235	286	Pass	9.0	3½	No
Grease C	Control	325	254	267	Pass	4.0	1	
	8.30×10^7	305	254	286	Pass	4.0	½	No
Grease D	Control	348	254	294	Pass	Pass	1	
	9.55×10^7	350	268	316	Pass	6.0	3	No

Table VI
Effects of Gamma Radiation on Non-Specification Greases

Type of Grease	Dosage (r)	Dropping Point	Penetration Unworked	Penetration Worked	Bomb Oxid.	Bomb Cu Corr.	Evap. Loss (%)	Oil Sep. (%)	Low Temp. Torque
Petroleum Base	Control	400	257	262	4	3	0.85	2.16	12
	8.35×10^7	360	235	275	10	0	0.67	5.14	5
Petroleum Base	Control	377	205	222	5	4	0.01	0.18	2
	9.97×10^7	373	201	233	9	1	0.48	1.92	2
Petroleum Base	Control	371	242	256	6	4	0.01	0.61	3½
	10.7×10^7	377	203	237	2	1	1.03	0.37	2
Silicone-Aryl Urea	Control	Over 500	324	330		0	0.05		20
	6.50×10^7	Over 500	391	382	6	0	0.56	1.66	½
Chloro-Phenyl Silicone-Aryl Urea	Control	Over 500	335	336	2		3.38	5.85	½
	8.90×10^7		Sample	Solidified					
Silicone	Control	425	265	286	0		2.08	2.00	¼
	7.6×10^7		Sample	Solidified					
Silicone	Control	437	307	335		1	0.92	2.76	¼
	11.7×10^7	401	410	Soupy	7	1	0.31	1.50	1

Table VII
Effect of Gamma Radiation on MLG 9305 Grease Penetration

Dosage (roentgens):	Unworked Penetration:	Worked Penetration:
0	347	335
1.0×10^6	343	331
3.0×10^6	347	346
1.0×10^7	347	346
3.0×10^7	369	366
6.5×10^7	391	382
1.0×10^8	422	414
3.0×10^8	444 (soupy)	455 (soupy)

Note: Grease becomes a rubber-like mass between 3×10^8 and 1×10^9 roentgens.

tion value down to zero penetration. The decrease in penetration noted for this grease and others may be due to a complex interaction between degradation products and the thickener-oil system. Before any conclusions could be drawn on the effect of radiation on consistency, it would be necessary to examine each individual grease over a range of radiation dosages.

A brief check was made on the high temperature performance of MLG 9305 irradiated to 6.5×10^7r. The control sample and irradiated sample were both run in a 204K Conrad-type 8-ball bearing at 10,000 rpm and 450° F.[2] The irradiated sample had an endurance life of 429 hours as compared to 311 hours for the control. This would indicate that at least for this grease the given dosage did not change its high temperature endurance.

Lubricants

The viscosity of the polymer-thickened MIL-O-5606 hydraulic fluid was adversely affected by gamma radiation. Values at —40° F. and 130° F. were approximately one-half the values of the unirradiated oil. Neutralization number changed significantly and oxidation-corrosion values indicated considerable degradation of the oil. In comparison with the MIL-O-5606 hydraulic fluid, Grade 1065 and 1100 engine oils showed only minor viscosity changes.

The synthetic-based hydraulic fluids gave somewhat different results than observed for MIL-O-5606 fluid. The chlorophenyl silicone-based fluid solidified at 1×10^8 roentgens. The silicate-based fluid MLO 8200 showed viscosity decreases for all temperatures except —65° F. A very slight neutralization number increase occurred with radiation, and the hydrolytic stability decreased somewhat. In the oxidation-corrosion test at 400° F., copper-beryllium

Table VIII
Effects of Gamma Radiation on MIL-0-5606 Hydraulic Fluid

Test:	Spec. Req.:	Control:	0.96×10^8 r:
Viscosity (cs)			
−40° F.	500 max	512.5	270.5
130° F.	10 min	10.16	4.32
Pour Point (°F.)	−75 max	Below −85	Below −85
Flash Point (°F.)	200 min	205	195
Autogenous Ig. Temp. (°F.)	None	604	600
Neutralization Number (mg KOH/gm of oil)	0.20 max	0.07	1.01
Evaporation at 150° F. for four hours of a thin film of the oil	Film of oil shall remain oily.	Oily	Oily
Rubber Swell (L Stock)	Between high and low reference fluids.	Pass	Pass
Oxidation-Corrosion (168 hr. at 250° F., 5 L/hr. of air)			
Weight Change (mg/cm²)			
Copper	0.6 (1)	−0.050*	−0.304**
Steel	0.2	0.000	0.355***
Aluminum	0.2	0.016	0.287***
Magnesium	0.2	0.330	0.389***
Cadmium-plated Steel	0.2	0.016	−0.897****
Percent Evaporation	None	5.98	6.78
Neutralization Number Change	0.20 max	0.05	9.15
130° F. Vis. Change	−5% to 20%	16.9	174.1

(1) Weight change can be a gain or loss; *Moderate tarnish-2D; **Dark tarnish-3-A; etching; ***Yellow discoloration; ****Yellow and dark brown discoloration; etching.

Table IX
Effects of Gamma Radiation on Synthetic Based Hydraulic Fluids

Test:	Chloro-Phenyl Silicone Hydraulic Fluid: Control:	Chloro-Phenyl Silicone Hydraulic Fluid: 1.16×10^8 r:	Silicate-Based Hydraulic Fluid (MLO 8200): Control:	Silicate-Based Hydraulic Fluid (MLO 8200): 1.01×10^8 r:
Viscosity (cs)				
400° F.	7.0		3.82	2.82
210° F.	22.1		12.1	9.57
130° F.				20.22
100° F.	62.5		33.8	29.1
−40° F.				776.6
−65° F.	2105		2557	2557
Pour Point (°F.)	Below −100		Below −100	−100
Flash Point (°F.)	585		415	430
Fire Point (°F.)	640		460	485
A. I. T. (°F.)			716	704
Neutralization Number (mg KOH/gm)	0.02		0.01	0.10
Percent Evaporation (400° F., 6.5 hours)	5.4		22.3	17.4
Rubber Swell, % (R Stock, 250°, 72 hr.)	−1.2		6	7
Hydrolytic Stability (25% H_2O, 48 hr., 200° F.)				
Cu. Wt. Change (mg/cm²):	0.0		−0.02	−0.015
Resistance to Hydrolysis				
130° F. Viscosity (cs)				
Before:				20.22
After:				24.10
−40° F. Viscosity (cs)				
Before:				776.6
After:				1270.4
Neutralization Number of H_2O:	0.02		0.02	0.11
Neutralization Number of Oil:				
Before:	0.02		0.01	0.10
After:	0.02		0.04	0.26
Percent Insolubles:	0.0		0.02	0.21
Oxidation-Corrosion (72 hr., 400° F., 5 L/hr.)				
100° F. Viscosity (cs)				
Before:				29.10
After:				34.22
% Change:				17.6
Neutralization No.				
Before:	0.02		0.01	0.10
After:	0.02		0.51	1.03
Change:	0.00		0.50	0.93
Percent Evaporation				8.86
Weight Change (mg/cm²)				
Copper-Beryllium				−0.643*
Stainless Steel	0.032		−0.05	−0.016
Aluminum	0.012		−0.04	−0.016
Chrome-Molybdenum Steel				−0.033**
Titanium				−0.016***
Silver	0.001		0.00	−0.016

Sample Solidified

*Peacock green and dark gray; **Purple discoloration; *** Light brown discoloration.

Table X
Effects of Gamma Radiation on a Diester Type MIL-L-7808 Lubricant

Test:	Control:	1 x 10^8 r:
Viscosity (cs)		
−65° F.	11,542	16,191
100° F.	14.1	16.4
210° F.	3.6	3.9
Viscosity Stability (at −65° F.)	Pass	Pass
Pour Point (°F.)	−75	−80
Flash Point (°F.)	440	380
Percent Rubber Swell ("H" Stock)	24.6	23.8
Percent Evaporation (400° F., 6½ hr.)	10.1	11.2
Foaming	Pass	Fail
Neutralization Number (mg KOH/gm)	0.5	11.6
Load Carrying Ability (lb./inch)	1930	3520
Corrosion (450° F., 50 hr.)		
Weight Change (mg/in^2)		
Silver	−1.5	−0.9
Copper	−3.0	−3.1
Oxidation-Corrosion (347° F., 72 hr.)		
Corrosion, weight change (mg/om^2)		
Silver	0.2	0.1
Steel	0.0	0.1
Aluminum	0.0	0.0
Magnesium	0.0	0.0
Copper	0.3	−0.6
Oxidation, acid number increase	0.7	4.4

corrosion was significant. Titanium, chrome-molybdenum steel, and copper-beryllium were slightly colored in the test. This fluid contained quinizarin as a metal deactivator and an alkylated diphenyl amine inhibitor. Coloring may have been due to degradation of these additives. A viscosity change of 17.6% for the 100° F. viscosity after the oxidation-corrosion test at 400° F. is considered satisfactory. Rubber swell ("H" stock) for MLO 8200 did not change significantly as a result of irradiation.

Irradiated MIL-L-7808 diester oil showed a viscosity increase at —65°, 100°, and 210° F. temperatures. A 60° (F.) reduction in flash point was observed. Changes in the oxidation-corrosion results were noted in the increased copper corrosion and the larger acid number increase. As a result of the irradiation, the neutralization number increases from 0.5 to 11.6 and the Ryder Gear Value increases from 1930 to 3520 pounds per inch of tooth face width. Bolt and Carroll[3] have previously reported an increase in lubricity of diester lubricants after exposure to neutron radiation. Fenske and Klaus[4] have shown that lubricity of diesters is markedly increased by the addition of a small amount of acid. Therefore, the improved lubricity after irradiation was caused by the chemical component rather than by an increase of the hydrodynamic component resulting from the viscosity increase. Since this Center has found that there is little effect on load-carrying ability over a significant temperature range, this indicates that the Ryder gear is not sensitive to small viscosity change.

Specification MIL-L-6082 lubricant Grades 1065 and 1100 were also irradiated to 1 × 10^8 roentgens. The viscosity increase and neutralization number change was far less for the petroleum engine oils than for the diester.

CONCLUSIONS

Grease structure and oxidation resistance of greases is affected by gamma irradiations of 1 × 10^8 roentgens. In each specification category, some materials appear to be usable. Radiation stability was not characteristic of a particular specification type. In each category, greases showed both radiation stability and instability. In order to determine if a given grease is usable when subjected to nuclear radiation, more complete testing over the entire radiation range would be required.

Table XI
Effects of Gamma Radiation on Specification MIL-L-6082 Engine Oils
Dosage: 1 x 10^8 roentgens.

Test	Grade 1065 Control	Grade 1065 Irradiated	Grade 1100 Control	Grade 1100 Irradiated
Neutralization Number (mg KOH/gm)	0.01	0.02	0.01	0.75
Viscosity (cs)				
100° F.	120	136	264	281
210° F.	12.3	13.6	20.2	21.0
Pour Point (°F.)	−5	−5	−5	−5
Flash Point (°F.)	455	445	495	485
Copper Corrosion (Air Well)	1-A	1-A	1-A	1-A
Conradson Carbon Residue (%)	0.58	0.65	0.17	0.40

Engine lubricants and hydraulic fluids showed viscosity changes as a result of irradiation. In the case of the polymer-thickened MIL-O-5606 fluid, a severe viscosity decrease took place. Only a slight decrease was noted for the silicate-based hydraulic fluid. The chlorophenyl silicone-based fluid solidified at 1 × 10^8 roentgens. The petroleum-base engine oils and the diester-base engine oil showed thickening after irradiation.

The oxidation-corrosion characteristics of engine oils and hydraulic fluids are adversely affected by gamma radiation. Specification MIL-O-5606 hydraulic fluid showed the greatest change, being severely degraded as evidenced by the neutralization number increase and the increase in metal corrosion.

Since only a limited amount of test data was obtained for each grease and lubricant tested, only trends could be established. Extensive evaluation would be required before any lubrication could be considered useful for applications in a nuclear radiation environment. Since the final test of any lubricant is in its performance, the chemical tests as described and used herein should only be considered as offering a quick screening technique. They should not be considered as finalizing a lubricant's usefulness.

BIBLIOGRAPHY

1. "Nuclear Chemistry and Effects of Radiation," *Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Vol. 7*, United Nations, New York, 1956.
2. "Lubricants, Liquid Fuels, and Related Products; Methods of Testing," Federal Test Method Standard No. 791 (formerly Fed. Spec. VV-L-791), December 15, 1955.
3. Bolt, R. O., & J. G. Carroll, "Lubrication in the Presence of Nuclear Radiation," *Lubrication Engineering, Vol. 12*, No. 5, November-December, 1956. p. 305.
4. Fenske, M. R., & E. E. Klaus, "Fluids, Lubricants, Fuels, and Related Materials," WADC Technical Report 55-30, Parts 1 through 4.

ACKNOWLEDGEMENT. The authors wish to express their appreciation to Mr. T. F. Davidson and Lieut. J. H. Way of the Power Plant Laboratory, WADC, for their assistance in supplying the engine oil data, and to Lieut. D. G. Harvey and Lieut. R. H. Johnson, Analysis & Measurements Branch, Materials Laboratory, WADC, for conducting the irradiation.

★ **ASLE-ASME 4th Lubrication Conference, October 7-8-9, Toronto** ★

Current Literature

"How to Select an Air Compressor" presents a new scientific, yet simple, method developed by the members of the Air Compressor Research Council for selecting an air compressor of the right type and size for specific requirements. The booklet discusses air compressor ratings, displacement and "free air," volumetric efficiency, types of air compressors, and types of operation. To enable one to select the right air compressor for the job, there are charts for determining cubic feet per minute required to operate various pneumatic equipment, cylinder diameters required to develop power to overcome indicated loads, volume of compressed air in cubic feet required per stroke to operate air cylinders, and flow of free air through orifices of various diameters. Use of the charts is explained with examples. Also included in the booklet are installation recommendations, maintenance instructions, and an explanation of compressed air terminology. (Air Compressor Research Council, 27 E. Monroe, Chicago 3, Illinois, price 50¢)

"Punch-Lok Catalog," No. 300RG-56, is more than a compilation of the company's standard-type hose clamps, grooved hose fittings, and special tools and replacement parts. It is also an instruction and training manual. Separate sections are devoted to detailed coverage of such subjects as Punch-Lok Method, Uses & Applications, and How to Apply Punch-Lok Clamps. (Punch-Lok Co., 321 N. Justine St., Chicago 7, Illinois)

Conversion Factor Chart. A reference table for engineers and other executives in wall-chart form has been published that is useful for engineers, shop men, and executives. Included are common conversions such as inches to centimeters, or watts to H.P., as well as many conversions that are difficult to locate in reference manuals. Some such examples are atmospheres to Kgs./sq.cm., cm./sec. to miles/hr., cu. ft. to liters, microns to meters, quintal to lbs., etc. (Precision Equipment Co., 3716 N. Milwaukee Ave., Chicago 41, Illinois)

"Inventors & Inventions," by C. D. Tuska, 135 pages, illustrated. Mr. Tuska, an expert on patents for RCA for a number of years, has written a manual that will encourage any reader's inventive tendencies, familiarize him with the psychology and methods of invention, and help him protect, patent, and market his inventions. To give the reader suggestions adaptable to the improvement of his own latent creative ability, the book describes some of primitive man's earliest inventions or discoveries, and the effects of environment, education, and age on inventions. (McGraw-Hill Book Information Service, 327 W. 41st St., New York 36, New York, price $3.75)

"Research — Key to Progress," a newly released 16 mm. color film available for showing by colleges, professional societies, civic organizations, and other groups, traces the rise and contributions of research, particularly by independent industrial research organizations such as the Armour Research Foundation. Arrangements for showing this 15-minute film can be made by writing to the Public Relations Dept., Armour Research Foundation, 10 W. 35th St., Chicago 16, Illinois.

"Corrosion Keys for Aluminum," a new and more convenient guide to engineers in determining the corrosion resistance of aluminum, makes extensive use of graphs which tell at a glance the yearly corrosion rate of more than 100 chemicals and other corrosive materials on aluminum. Although the brochure is intended primarily as an aid to engineers designing aluminum into process plants or equipment, it is also of interest to those concerned with other applications of the metals. (Reynolds Metals Co., 2500 S. 3rd St., Louisville, Kentucky)

"CaPlug File," a newly-revised, illustrated file folder, presents the recently expanded line of CaPlugs (Polyethylene closures). Tabbed and punched for handy reference in file cabinet or binder, the folder summarizes important data on the entire line of threaded and non-threaded caps and plugs for safeguarding products in process, storage, and transit. Enclosed in the folder are dimension and price sheets for over 300 stocked sizes of the 10 standardized designs used to protect tubing, valves, hydraulic components, numerous machined parts, and fittings on products of every type. (CaPlug Div., Protective Closures Co., Inc., 2207 Elmwood Ave., Buffalo 23, New York)

"Dow Corning Silicone Fluids," a new reference brochure describing the physical and electrical characteristics of all the company's silicone fluids now commercially available, includes brief general descriptions of each fluid plus general application information. Data are arranged in tabular form, and include such standard properties as specific gravity, pour point, thermal conductivity, surface tension, refractive index, dissipation factor, and even specific heat. (Bulletin 3-106, Dow Corning Corp., Midland, Michigan)

"Flexon Flexible Connectors," Bulletin No. 158, offers complete information on how to adsorb vibration, dampen noise, reduce piping failure, and prevent leakage. Material specifications, pipe sizes, and fitting connections are shown as well as operating pressures and maximum off-set allowed. A diagram showing proper installation procedures is pictured. (Flexonics Corp., 1415 S. 3rd Ave., Maywood, Illinois)

★ ASLE-ASME 4th Lubrication Conference, October 7-8-9, Toronto ★

Use of Rolling Contact Bearings in Low Viscosity Liquid Metal Lubricants

The investigations described herein cover the use of rolling contact bearings submerged in and lubricated by either liquid sodium-potassium alloy or liquid sodium. Tests were conducted to determine the effect of thrust load on the bearing with respect to bearing life. Various materials of construction and bearing design were used, and the effects of these variables were measured.

W. Markert, Jr. & K. Mildred Ferguson
Babcock & Wilcox Company
Research Center
Alliance, Ohio

Power plant systems using liquid metals as the heat transfer fluid usually require the application of rotary motion for various components such as pumps and control mechanisms. The necessity for an almost complete freedom of leakage both to and from such systems makes it desirable to enclose the drive mechanisms, bearings, and other working parts in the liquid. By this means, it is possible to design a mechanical system which is completely sealed from the atmosphere.

While the problems of leakage may be solved in this manner, it now becomes necessary to lubricate the bearings with the liquid metal. These fluids have very poor lubricating properties and, generally, have a low viscosity which would tend to make satisfactory operation relatively difficult to obtain. In addition, the application usually requires bearing operation at a temperature of approximately 250° F., which is above that normally encountered in service.

One of the primary applications for the rolling contact bearings was to support the rotor and impeller of an enclosed rotor centrifugal pump. During the early part of this work, a small pump of this type was constructed and operated at a speed of 1750 rpm with sodium-potassium alloy as the lubricating fluid. The bearings in this case were a 306-R single row ball bearing and a 7207 duplex ball bearing. Ribbon-type retainers were used initially, but these proved unsatisfactory because of wear and breakage. These were replaced with retainers which were machined from solid SAE 1010 steel. Bearings of this type were operated successfully for a period of 5000 hours, at which time an examination disclosed only superficial damage of the balls and races and only slight retainer wear. The ball path on the races and the balls were very similar in appearance to that which would have been obtained with normal oil lubrication. The loads on the bearing in this case were very low (approximately 30 lb. radial and 30 lb. thrust), which was undoubtedly a major factor in obtaining satisfactory life.

Since ball bearings appeared to be satisfactory in small sizes and under light loads, it was decided to carry the investigation further and to determine the suitability of larger size bearings which would be capable of supporting heavier loads. Of interest were thrust loads in the range of 500 to 1000 pounds, and relatively light radial loads at a speed of 850 rpm. Satisfactory operation under these conditions would make it possible to use large-size enclosed rotor centrifugal pumps with rolling contact bearings for service with sodium-potassium alloy.

TEST APPARATUS

The problems imposed by the use of sodium-potassium alloy precluded the use of standard bearing testing equipment. The affinity of the liquid alloy for the atmosphere made it necessary to enclose the test bearing and the alloy in a sealed container. Since the primary load for the final

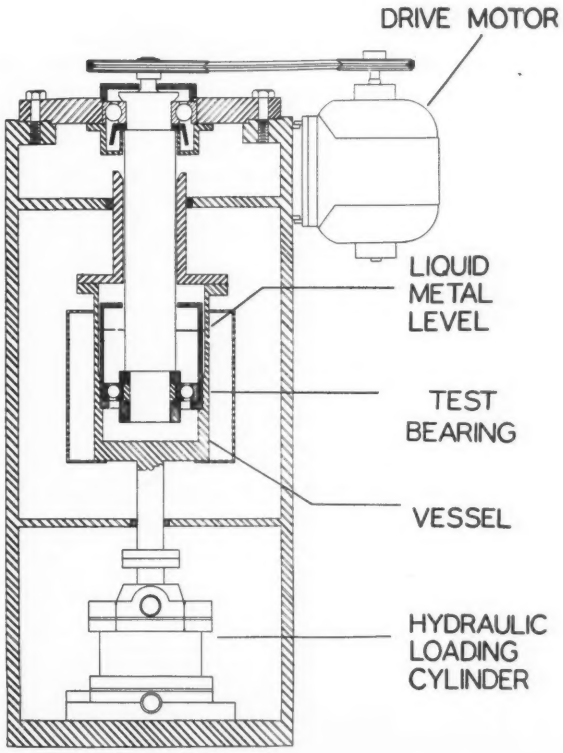


Figure 1. Bearing Test Apparatus for thrust loads.

This paper was presented under the sponsorship of the American Society of Lubrication Engineers before the Third Annual ASLE-ASME Lubrication Conference, Atlantic City, October 8, 1956.

application was axial thrust, most of the bearing testing equipment was designed for this type of load only. Some equipment was provided, however, for pure radial loads and for combined radial and axial thrust loads.

A sectional drawing of the apparatus used for the testing of the rolling contact bearings under conditions of pure thrust loads is shown in Figure 1. This tester could accommodate bearings with a minimum bore of 50 mm and a maximum outside diameter of 250 mm, with thrust loads up to 10,000 lb. The inner race of the test bearing is mounted on the lower end of a vertical shaft, and the outer race is mounted in a vessel which is partially filled with the liquid metal. This vessel is mounted between cylindrical bearings in such a manner that it is free to move axially. The thrust load is applied to the test bearing by a hydraulic cylinder which pushes upward on the vessel and the outer race of the test bearing. This upward force is transmitted through the bearing to the shaft and is resisted by an oil-lubricating ball bearing mounted at the top of the shaft. The shaft is driven by an induction motor through "V" belts so that the speed may be adjusted by varying the pulley diameters.

The vessel, which contains the test bearing, is surrounded by an oil bath which is heated by electrical immersion heaters. This serves to maintain the temperature of the sodium-potassium alloy bath at the desired level.

The liquid sodium-potassium alloy in the vessel was protected from the atmosphere by providing a continuous flow of prepurified nitrogen through the top of the vessel. This gas flowed to the atmosphere through a long thin annulus surrounding the shaft and effectively sealed off back-diffusion of the atmosphere into the vessel. A rubber "O" ring seal was also provided between the shaft and the vessel lid so that the inside of the vessel could be evacuated prior to filling with the liquid metal.

A system of baffles was installed in the vessel to restrain the rotation of liquid metal during operation and, thereby, prevent the test bearing from being uncovered and running dry. A slinger was installed on the shaft to prevent the liquid metal from entering the annulus with the sealing gas.

All parts of this equipment which were exposed to the liquid metal were constructed of stainless steel in order to prevent serious cumulative corrosion during the many cleaning operations which would take place during the life of this equipment. Since stainless steel has a much higher coefficient of thermal expansion than the SAE 52100 steel used for the bearings, modifications in the room temperature fit of the bearing on the shaft and in the housing were made to provide the proper fit at the operating temperature of 250° F.

TEST RESULTS

The greatest portion of this investigation was performed on ball bearings in sizes ranging from a bore of 50 mm to 140 mm at a speed of 850 rpm. Most of the tests were run with axial thrust loads from 400 to 4300 lb. with sodium-potassium alloy at a temperature of 250° F. as the lubricant. In all cases, the load-carrying members were made of SAE 52100 hardened in the usual manner for bearing applications.

In the early stages, it was found that the primary cause of bearing failure was the wear of the retainer against the load-carrying members. This wear was far in excess of that normally encountered with oil- or grease-lubricated bearings because the sodium-potassium alloy does not possess the required lubricating properties for the boundary conditions between the balls and the retainer. In order to alleviate this condition, various retainer materials and designs were investigated in addition to various standard bearing types. It was desirable to use materials for the retainer which were compatible with the SAE 52100 load-carrying members so that a minimum of metal wear and metal transfer would occur. The various bearing types were investigated in an attempt to minimize the loads between the balls and the retainers and, thereby, reduce the amount of damage to these members.

In most cases, each bearing type and retainer material

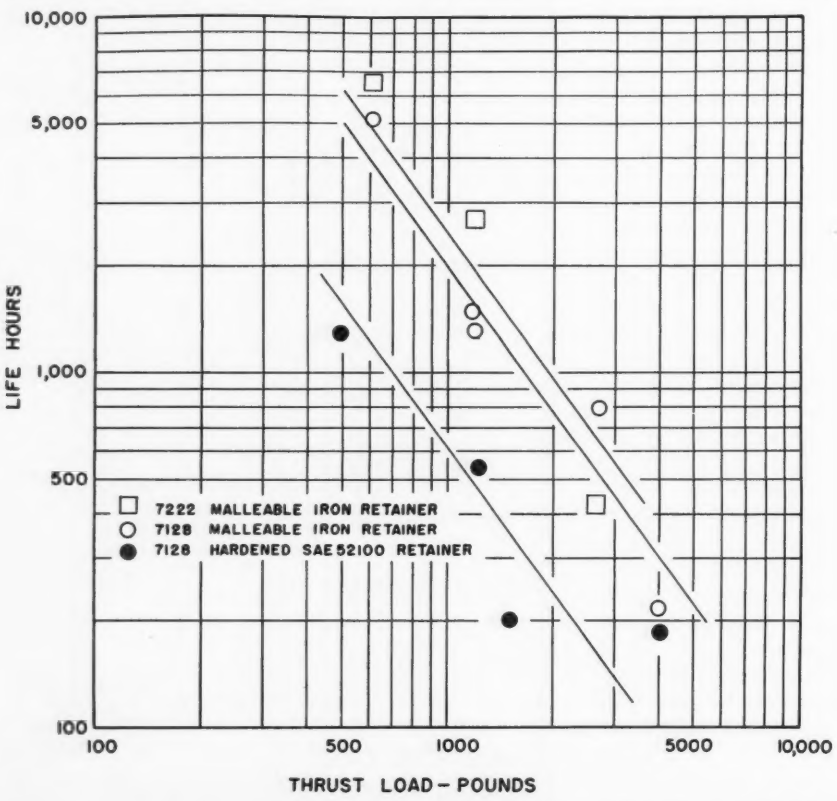


Figure 2. Life vs. Load for representative ball bearings operating at 850 rpm with sodium potassium alloy lubrication.

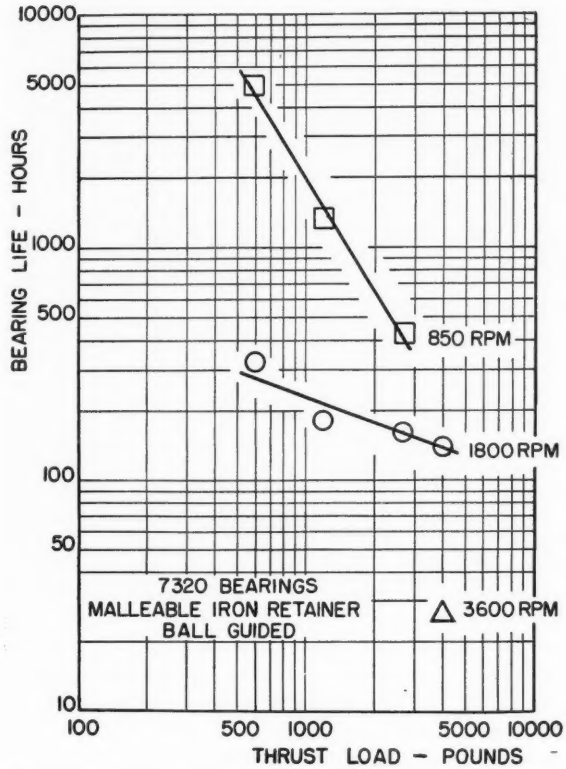


Figure 3. Comparison of bearing life at various speeds.

was tested over a wide load range so that the effect of load on life could be determined. The life of a group of representative ball bearings is plotted as a function of load in Figure 2. It will be noted that the dispersion of these data points from the regression lines is considerably less than that which would be expected if the life were controlled by normal fatigue failures instead of being a function of rates of wear and metal transfer. This rather good consistency in life was of great assistance in this investigation, since it was possible to evaluate the relative suitability of a particular bearing or retainer material with far fewer tests than is required in normal bearing testing.

It was found that the slope of the regression line on logarithmic coordinates was virtually independent of the various parameters of design and retainer material. Therefore, the data were fitted with regression lines of constant slope and the following relationship for life and load was established:

$$\log \text{life} = A - 1.37 \log \text{load}$$

In this case, the value of the term A may be considered an index of the relative worth of a particular bearing and may be used directly in comparing the effectiveness of various designs or materials. The value of A was determined by test for a group of retainer materials in 7128 size bearings. These results are given in Table I.

Table I

Value for A For Various Retainer Materials in a 7128 Ball Bearing

Retainer Material	A
SAE 1040	7.10
SAE 1052	6.87
SAE 50100	6.95
SAE 52100	6.90
Malleable Iron	7.40
Maxel 1B	7.50
24-S Aluminum	7.1

While the range of values for A in Table I does not appear to be very great, it should be noted that this is a constant term in a logarithmic function and, therefore, the effect on bearing life is considerable.

The value of A was also determined for a range of ball bearing sizes and types all equipped with malleable iron retainers as shown in Table II.

In Table II, the bearings have been arranged in order of increased load-carrying capacity with normal lubrication. The values of A or the load capacity with sodium-potassium alloy lubrication, however, are in a different order, which indicates that those factors normally producing high capacity are not as significant with this unusual lubricant. Of particular interest here is the relatively low capacity of the 7418 bearing as compared with the 7222 or the 418-R bearing. The stresses on the load-carrying members of 7418 bearing are lower than the others because of the larger size or a larger contact angle. The effect of contact stresses is apparently overshadowed by other factors which have a greater effect.

A comparison of the values of A as given in Table I and Table II show that material used for the retainer has as much, if not more, effect on life as the bearing size and the bearing type. The importance of retainer material was further demonstrated in a limited number of tests on 222-R bearings using Micarta instead of the metallic retainer materials previously used. Micarta exhibits satisfactory corrosion resistance in sodium-potassium alloy at 250° F., and has physical properties such that the wear and metal transport problems encountered with other materials are alleviated. The value of A obtained in this case was 8.4, which corresponds to a life approximately four times as great as any other bearing-retainer material combination investigated. Unfortunately, time did not permit a more intensive investigation of Micarta or other non-metallic retainer materials. However, it is significant that when the damage to the load-carrying members by the retainer was largely eliminated, the bearing life increased considerably.

A limited amount of testing was done to investigate the effect of bearing speed on the performance of a 7320 ball bearing with a malleable iron retainer. The results obtained are shown in Figure 3. This data shows that the life of the bearing is very dependent on the speed, as may be expected under conditions of poor lubrication and fully submerged operation. A comparison of the 850 rpm and the 1800 rpm tests show that the slope of the life vs. load line differs considerably, indicating that the life becomes less dependent on load as the speed increases.

Table II

Value of A For Various Ball Bearings With Malleable Iron Retainers

Bearing Size	A
7128	7.40
7222	7.45
418-R	7.60
7320	7.40
7418	6.85

MECHANISM OF BEARING FAILURE

The limited lubricating properties of sodium-potassium alloy produced a type of bearing failure which differed from that normally encountered with oil or grease lubrication. This failure was associated primarily with wear of the retainer and the transfer of retainer material to the load-carrying members. The transferred material formed high spots or elevations on the normally smooth surface and thus introduced localized stresses on both the balls and races sufficient to cause surface cracking. Further operation of the bearing resulted in severe cracking and, finally, jamming of the bearing.

Figure 4. Surface of ball showing film loosened and partially removed by nitric acid. (10x)

Figure 5. Retainer material adhering to ball; very light picral etch. (500x)

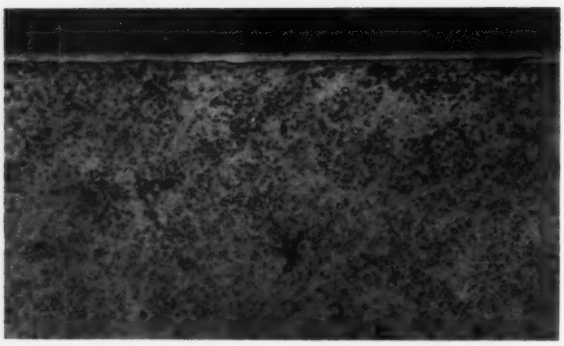


Figure 6. Retainer material adhering to outer race; picral. (500x)

During the initial phases of operation, the normally fine surface finish on the balls and races was virtually improved by the distortion, flow or removal of fine metal particles. The load-carrying members became covered with an extremely thin film of fine particles of metal and metal oxide. As long as this film was continuous and uniform, the bearing continued to operate satisfactorily. An example of this film is shown in Figure 4 after it had been loosened and partially removed from the surface of the ball by the action of nitric acid. The general appearance of this film was apparently independent of the metal used for the retainer.

The wear of the retainer by the balls was a continuous process, and with longer operation the surface film on the balls increased in thickness. This foreign material on the balls was transferred in quantity also to the races. Examples of retainer material adhering to the balls and races are shown in Figures 5 and 6. At this stage of the bearing life, the operation of the bearing appeared to be quite normal.

With further operation, however, these surface films became discontinuous as small areas separated from the surfaces. An example of this type of film is shown in Figure 7. The discontinuous and rough nature of the surface of the load-carrying members caused stress concentrations to rise. These surface stresses would be expected to have values considerably higher than those encountered in normal operation and could cause the formation of very small cracks.

A number of bearings have been examined metallographically at this stage of their life. These all showed the same type of surface failure regardless of the metal used for the retainer, although certain metallic retainers required longer operation to reach this stage than others. A photograph showing the general appearance of an outer race with the discontinuous surface film is given in Figure 8. It will be noted that this film is not uniform over its width, and that it has more severe discontinuities appearing near the bottom of the race. This zone is apparently subjected to heavier metal transfer and higher stresses, and most failures are initiated in this area.

A section through the bottom of this outer race is shown in Figure 9. The small cracks which are visible on the surface correspond to the spacing of the surface dis-

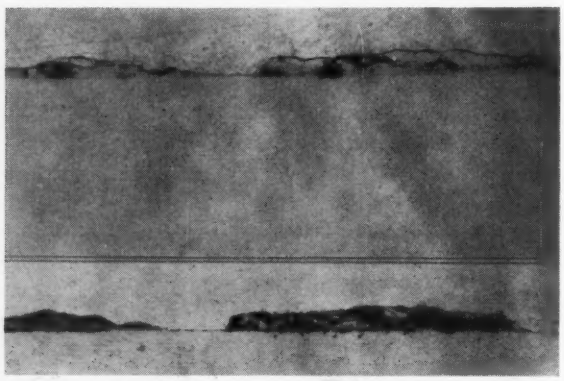


Figure 7. Discontinuous film on outer race. (500x)

Figure 8. Ball path, outer race; oblique illumination. (10x)

continuities shown in Figure 8 and, apparently, are closely associated with the stress concentrations which would arise from the roughened surface. The films previously seen on sections through the surfaces have been largely removed by the action of the balls rolling and sliding in the races so that only a generally roughened surface remains.

An example of another race in which the cracking had proceeded further is shown in Figure 10. In this case, the matching surface view of the race is also shown and it may be seen that the cracks correspond exactly with the surface discontinuities. It is particularly significant that all of the races examined in this condition exhibited cracks at the same general angle to the surface and that these cracks corresponded to the discontinuities in the surface. In none of the many bearings examined were any sub-surface cracks observed. All cracks extended inward from the contact surface.

All of the surface cracks found on these bearings proceeded inward from the surface in the direction of rolling of the balls in the races. These cracks had a close resemblance to surface failures found by Dr. S. Way[1] in his investigation of the failure of rolling members lubricated by low viscosity fluids. The explanation given by Dr. Way for the failures appears to be equally applicable to the case of ball bearings lubricated by sodium-potassium alloy, i.e., the fluid enters small incipient cracks and is subjected to high hydrostatic pressures as the area is loaded. This high pressure causes the crack to extend and deepen until a critical size is reached and a particle of metal is removed from the surface.

This type of failure was generally found on the inner and outer races, but small cracks of this type were only occasionally observed on the surface of the balls. This could be due to the larger available surface area of the balls as compared to either race and the distribution of the damaging effects over a larger area.

Most of the bearings in this investigation were tested beyond the point of failure described above so that much

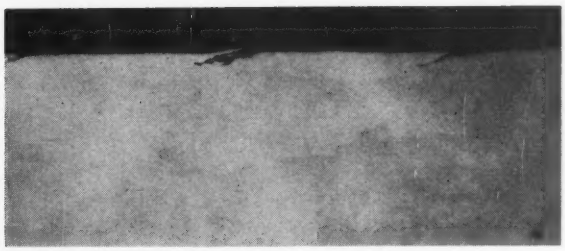


Figure 9. Circumferential plane through cracks in outer race; as polished. (250x)

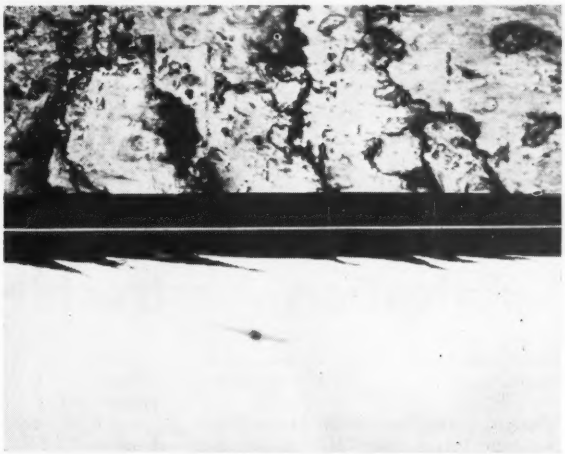


Figure 10. (top) Direct view of ball path; (bottom) polished plane through path. Direction of rolling ➤➤ (500x)

Figure 11. Outer race ball path. Direction of rolling ➤➤ (5x)

more severe race and ball damage was encountered. With further operation, the small cracks progressed into a network of deep cracks as shown in Figures 11 and 12. At this stage, the surface of the load-carrying members became very rough and the consequent stress concentrations very high. Major pits would form in the surface of the races and, on occasion, one or more balls would pit or crack. The retainer wear was usually quite severe by this time and in some cases, particularly with soft metallic retainers, the web separating the ball pockets was completely worn away.

The bearings which were tested with Micarta retainers did not exhibit a film formation or small cracks such as those described for metal retainers. No evidence could be found of material transfer to the load-carrying members, and the bearing life was much longer than that obtained

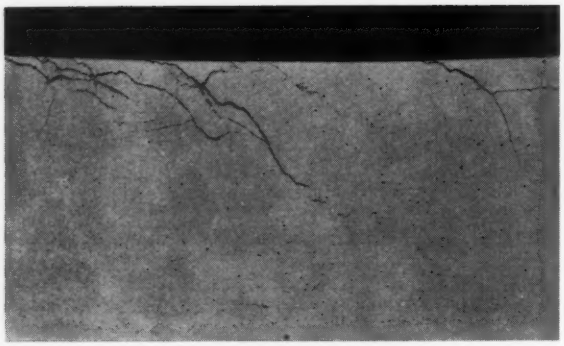


Figure 12. Polished plane through ball path of Figure 11. Direction of rolling ▶▶ (10x)

with any of the metallic retainers, although it was somewhat below rated life with normal lubrication. The failure in this case more closely resembled the fatigue failures found with normal lubrication.

SUMMARY

It appears that the major cause of bearing failure was the metallic retainer which provided foreign material to the races and caused stress concentrations and consequent failure by cracking. The low viscosity lubricant then promoted this cracking which finally progressed to shattering and complete failure. The use of non-metallic retainers apparently offers promise in alleviating the cause of failure. The load-carrying capacity of ball bearings with sodium-potassium lubrication is sufficient, however, for many cases where long life is not required.

BIBLIOGRAPHY

1. Way, S., "Pitting Due to Rolling Contact," *Journal of Applied Mechanics, Vol. 57,* 1935.

ACKNOWLEDGEMENTS. The bearing investigations reported here were done as part of Contract NObs-34222 under the direction of Code 1500, Bureau of Ships, Department of the Navy.

Lubrication Abstracts

(Compiled by the ASLE Abstracts Sub-Committees.)

"Designing Oil Grooves for Sleeve Bearings," by J. B. Mohler, *Machine Design, Vol. 28,* No. 14, July 12, 1956, pp. 99-102.

The purpose of oil grooves and the factors that must be considered in their design are discussed in considerable detail. Starting with the premise that the formation of a hydrodynamic film must be promoted, the general requirements of adequate oil flow, oil entry to grooves, groove depth, cross-section, groove location, and configuration are described. The advantages of an oil exit or "mud pocket" for cooling and for clearing dirt from bearings with a pressurized oil supply are noted. Measures that may be tried to assure an adequate oil film to parallel-surface thrust plates are mentioned. *(Abstracter: F. J. Kolano)*

"How Much Grinding Fluids Affect Wheel Performance," by J. A. Mueller, *Iron Age,* (Part I) *Vol. 179,* No. 9, Feb. 28, 1957, pp. 79-81; (Part II) *Vol. 179,* No. 10, March 7, 1957, pp. 134 & 135.

Part I. A variety of grinding fluids is investigated. Criteria considered are: (1) amount of metal removed, (2) wheel wear, (3) power consumed, (4) work piece finish, (5) cutting rate. Grinding oils excelled water-soluble oils. Use of grinding oils allows heavier cuts and gives finer finish. Test data suggests that dry grinding could frequently replace wet grinding. CO_2 "snow" is found to be comparable to a water-soluble oil as a grinding coolant.

Part II. Grinding wheel performance is influenced by both the type of fluid being used and method of application. Comparative tests are made with mist, flood, and jet stream application. The order of efficiency (highest grinding ratio) found is as follows: (1) grinding oil with jet stream, (2) grinding oil with flood application, (3) water-soluble oil with jet stream, (4) water-soluble with flood application. *(Abstracter: W. J. Wojtowicz)*

"Ion Formation & Inhibition in Hydrocarbons," by A. Gemant, *Appl. Sci. Res., Vol. 6A,* No. 1, 1956, pp. 1-14.

Oxidation of hydrocarbon oils is accompanied by increase in electrical conductivity. This phenomenon is of particular interest in application of oils as electrical insulation. Mild oxidation with ozone is carried out on a number of aromatic compounds in both polar and non-polar solvents. Increase in conductivity is found only when small amounts of aliphatic acid or cholesterol are present. Olefins or alcohols are found to inhibit the ion-forming mechanism. Ultraviolet absorption spectra indicate the possibility that inhibition results from competition of the alcohols or olefins for ozone. Since ionic species are intermediate products, conductivity returns to lower values as the "depth" of oxidation is increased. *(Abstracter: E. S. Francis)*

"Oil Groove Design in Bearings," by S. Kyropoulos, *Machine Design, Vol. 28,* No. 12, June 14, 1956, pp. 119-122.

The function of oil grooving in the long bearings antedating the application of hydrodynamic theory, and in modern designs, is reviewed. The effects of axial and circumferential grooves on the load capacity of bearings with unidirectional and with rotating load are described. Modern practice stresses the avoidance of grooves that connect areas of high and low pressure in a bearing, but in some designs a central circumferential groove can improve performance by increasing operating viscosity through improved cooling. Similar exceptions to conventional practice can often be justified by special mechanical requirements. Several views regarding the best position for the oil inlet in crankpins are compared. *(Abstracter: F. J. Kolano)*

"Relation Between the Exponent x in the Formula $\log \nu = A/T^x + B$ & the Structure of Saturated Mineral Oil Fractions," by J. Cornelissen & H. I. Waterman, *Fuel, Vol. 35,* No. 4, 1956, pp. 433-436.

Previously the authors had shown a relationship between log ($\nu 20/\nu 70$), refractive index, and the total ring content of hydrogenated mineral oil fractions. This is an extension to show a relationship between the value of the exponential x in the defining equation and the total ring content. *(Abstracter: E. S. Francis)*

"Trends in Sleeve Bearing Materials," by J. B. Mohler, *Machine Design, Vol. 28,* No. 11, May 31, 1956, pp. 108-110.

The general physical properties required of a bearing material as established by experience are noted. Special applications for which powder metals, aluminum, graphite, and plastics are better suited than established bearing materials, are then reviewed. Although the newer materials possess properties that permit their use alone in bearings, in some cases they must be modified by such methods as surface filling, gridding, impregnation, overlaying, or lining to obtain the most desirable combination of hardness with conformability, plasticity, and low coefficient of friction. *(Abstracter: F. J. Kolano)*

"Viscosity-Temperature Characteristics of Mineral Oils & Their Structive," by J. Cornelissen & H. I. Waterman, *Fuel, Vol. 35,* No. 3, 1956, pp. 291-294.

The viscosity-temperature relationship is defined by the equation $\log \nu = A/T^x + B$ where ν = kinematic viscosity in centistokes, T = absolute temperature, and

(Continued on p. 295)

Technical Services Abstracts

(The following reports of research for the Armed Forces have been recently released for industry use, and may be obtained at the prices indicated by writing: Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.)

Ellipsometry: (1) General & Theoretical Considerations, (2) Application to the Fundamental Examination of Adhesion, by R. L. Patrick, D. A. Ross & W. A. Vaughn, Quantum, Inc., for Wright Air Development Center, March 1956, 44 pages. New fields of investigation in the biological, chemical, and physical sciences have been opened up by the ability to measure films in terms of their molecular thickness. A simple, versatile tool for determining these thicknesses is the ellipsometer, or polarizing spectrometer. Precise determinations to a few Angstroms are possible, and a number of these instruments are now in use. The device is particularly effective for examination of adhesive-adherend systems, friction and lubrication corrosion, reaction kinetics, and mechanisms of many reactions. This report contains a discussion of the fundamental background and theory of ellipsometry. An investigation of the phenomenon of adhesion was conducted, and model systems were prepared. An ellipsometer was designed, constructed, calibrated, and used as a research tool for the study. Preliminary work was undertaken to determine precise locii of adhesion rupture with the aid of ellipsometry. (Order No. PB-121663, price $1.25)

Further Investigation of Disturbances due to Oil Films in Journal Bearings, by J. F. Lewis & G. B. Fulton, Rensselaer Polytechnic Institute, for Wright Air Development Center, May 1956, 29 pages. Instability characteristics are described for two flexible rotors with critical speeds of about 1300 rpm. running in six journal bearings. The whirl impending speeds, with a few exceptions, were near twice critical. A slight decrease in whirl impending speed was noticed with decreasing viscosity. No stable range was observed above the speed at which whirl set in. The ratio of the maximum stable speed to the critical speed is plotted as a function of inlet oil viscosity. A photographic method for determining the running position of a journal bearing is described, along with several determinations of running speed position. Some interesting trends of whirl impending speed with L/D ratio, clearance, and temperature are presented. (Order No. PB-121519, price 75c)

Investigation of the Nature of the Forces of Adhesion, by L. R. Brantley & J. Charnell, Occidental College, for Office of Naval Research, June 1955, 89 pages. Many methods have been devised for the measurement of adhesion by coating-substrate separation. Effective among these is the Interchemical Adherometer, a chisel-type instrument which measures the force necessary for a knife to scrape off a coating of a certain width from a substrate. This investigation reviews the latest refinements in technique and interpretation of this type of measurement, and examines the relation of Adherometer adhesion, or "hesion," of other properties of a lacquer coating on a non-ferrous substrate. Evaluation of bulk shear through the friction properties of the coating received particular attention. (Order No. PB-121555, price $2.25)

Studies on Ball Bearing Steels, II: Effect of Some Metallurgical Factors on the Life of Ball Bearing Steels, by T. Mitsuhashi, M. Ueno & Y. Nakano (National Institute of Industrial Technology of Japan), translated by W. K. Y. Tao, University of Alabama, for Bureau of Ships, U. S. Navy, July 1956, 17 pages. Improvement in the life of Japanese domestic ball bearings was sought through a study of the relationship between metallurgical factors and life-span. Bearing trouble has been occurring mainly at the inner ring, next on the ball, and then on the outer race. Using inner rings whose life-span has been determined, tests were run on chemical composition, non-metallic inclusions, hardness, compressive loading, cementite content, grain size, and degree of forging. Results showed that chemical composition, nitrogen content, and grain size bore no direct relationship to life. Residual cementite after heat treatment had a clear relationship. The life of the bearing was extended as hardness increased after heat treatment. The forging ratio of Japanese ball bearing steels was found to be considerably below that of similar foreign steels. (Order No. PB-121427, price 50c)

Survey of the Literature on Antioxidants & Anticorrosion Additives for Lubricants at Elevated Temperatures, by J. W. Cole, Jr., A. Burger & A. F. Benton, University of Virginia, for Wright Air Development Center, May 1954, 830 pages. This bibliography of 2500 items was compiled from a survey of literature between 1916 and 1952 on high-temperature oxidation and corrosion inhibitors for synthetic and natural lubricating oils. Media such as rubber were included where the effects might have analogies in synthetic-base lubricants. Inhibiting compounds are listed in tables according to empirical formula, in conformity with the arrangement in "Chemical Abstracts." The tables also contain data for each compound regarding structural formula and name, the compound protected by the antioxidant, maximum test temperature, metals used, preparation of the antioxidant agent, temperature data, pertinent miscellaneous information, and references to the literature. A special listing is made of all compounds cited in the literature as inhibitors at 300° F. or higher. The bibliography may be kept current by use of the yearly index of "Chemical Abstracts." (Order No. PB-121726, price $10.00)

Synthesis & Antioxidant Activity of Some New Polyfluoroalkyl Sulfides & Selenides, by P. D. Faurote, C. M. Murphy, J. G. O'Rear & H. Ravner, Naval Research Laboratory, November 1956, 15 pages. Fluids capable of effective lubrication at temperatures of 400° F., or higher may require oxidation inhibitors with properties which differ considerably from those of additives in present use. Two new fluoroalkyl selenides and a sulfide were synthesized in this research by thermally induced reactions of $H(CF_2CF_2)_nCH_2I$ with sulfur and selenium and tested as high-temperature antioxidants. A free radical mechanism involving the homolytic cleavage of the C-I bond was postulated to explain the products of the reactions. Neither the bis(1H,1H, 7H-dodecafluoroheptyl) sulfide nor selenide displayed inhibition activity in bis-(2-ethylhexyl) sebacate. At 482° F., bis-(1H,1H,11H-eicosafluoroundecyl) selenide did not inhibit the oxidation of bis(1H,1H,7H-dodecafluoroheptyl) 3-methylglutarate. Both selenides apparently decomposed under test conditions to give products which can attack the glass system. (Order No. PB-121568, price 50c)

Water Bearings & Air Bearings with Pressure Lubrication, by Fr. Gottwald (Techn. Hochschule, Darmstadt, Germany), translated by F. Rizzo, for Bureau of Ships, U. S. Navy, July 1955, 13 pages. Water or air fed into a bearing under pressure acts as a safe load-carrying film of lubricant which can be maintained even at low rotational speeds, at which the conventional slide bearings cannot retain the hydrodynamic lubricating film. Construction and operation of a conical bearing which can be operated with water or air are described. Results of calculations and experiments are included. Application of an air bearing for the cardanic suspension of the gyro-compass is discussed. (Order No. PB-121405, price 50c)

★ **ASLE-ASME 4th Lubrication Conference, October 7-8-9, Toronto** ★

Patent Abstracts

(Compiled by Ann Burchick, Aluminum Co. of America.)

Lubricating Oil Additives & Process of Making Same, Patent #2,758,069 (W. B. Whitney, assignor to Phillips Petroleum Co.) In a process for producing lubricating oil detergent additives by the oxidation, with a gas comprising free oxygen, of a lubricating oil fraction at a temperature above 200° C., the improvement which comprises catalyzing the oxidation reaction with the product obtained by reacting a phosphorus sulfide with a terpene, whereby oxidation time is reduced and a superior additive is produced.

Method for Incorporating Oil-Insoluble, Solid Addition Agents in Mineral Oils, Patent #2,758,085 (E. A. Oberright, assignor to Socony Mobil Oil Co., Inc.) A method for incorporating an oil-insoluble, solid, addition agent into a mineral oil fraction, which comprises (1) comminuting the addition agent to an average particle size no greater than about 45 microns, (2) forming a compacted pellet comprising from about 10% to about 90%, by weight, of the comminuted addition agent and from about 90% to about 10%, by weight, of a wax binder, and (3) adding the said pellet to the mineral oil fraction.

Lubricant Composition, Patent #2,758,086 (F. A. Stuart & W. Lowe, assignors to California Research Corp.) A lubricant composition comprising a major portion of an oil of lubricating viscosity and a minor percentage, sufficient to impart detergent qualities to the oil, of at least one amino compound selected from the group consisting of (1) alkyl amines having attached to the amino nitrogen atom at least one branched chain alkyl radical having at least 10 carbon atoms, said alkyl radical being attached to the amino nitrogen atom through a tertiary carbon atom, and (2) salts of said amines and an organic acid selected from the group consisting of oleic acid, cetyl maleic acid, and alkane phosphonic acid derived from petroleum white oil, said composition being characterized by low corrosivity to bearing and other metal surfaces.

Noncorrosive Lubricating Oil Composition, Patent #2,758,087 (P. S. Landis, assignor to Socony Mobil Oil Co., Inc.) A mineral lubricating oil containing (a) a minor proportion, sufficient to inhibit oxidation of said oil, of a phosphorus- and sulfur-containing reaction product formed by reacting 1 mole of phosphorus pentasulfide with from about 2 to about 10 moles of an olefinic hydrocarbon material having a molecular weight of from at least about 135 up to about 450 and containing upwards of about 25% olefins, at a temperature of from about 100 to about 250° C., and for a time period of from about 1 to about 10 hours, and (b) zinc tallate, in an amount to supply to the oil from 100 to 200 parts of zinc per 1000 parts of sulfur present in the oil due to said phosphorus- and sulfur-containing reaction product.

Penetrating Oil Composition, Patent #2,758,088 (J. H. Bartlett, D. L. Cottle & H. C. De Hoff, assignors to Esso Research & Engineering Co.) An improved penetrating oil which comprises a mineral oil base stock containing combined therein a minor amount, sufficient to improve the penetrating power thereof, of a material having the formula: $RCH(XR')_2$ wherein R and R' are alkyl radicals having from 4 to 18 carbon atoms and wherein X is selected from the class of oxygen and sulfur.

Lubricants, Patent #2,758,089 (M. C. Hoff, R. W. Watson & E. K. Fields, assignors to Standard Oil Co.) A composition consisting essentially of the product resulting from the reaction of (1) hydrogen peroxide, (2) a compound selected from the group consisting of molybdenum and vanadium compounds capable of affording an oxide of the respective metal under reaction conditions, and (3) an unneutralized phosphorus sulfide-hydrocarbon reaction product at a temperature in the range of from about 25 to about 200° F.; said three components of the reaction being contacted in the following approximate proportions based upon one part of component (2), 1 to 40 parts of component (3), and 0.05 to 4 parts of component (1).

Lubricating Compositions, Patent #2,758,091 (W. C. Webber, assignor to Shell Development Co.) A lubricating composition consisting essentially of a major amount of a lubricating oil and a minor amount sufficient to impart extreme-pressure properties thereto, of a dihydrocarbyl trihalomethyl-l-arylalkyl phosphite.

Hydrogenation of Aromatics & Sulfur-Bearing Hydrocarbon Oils & Catalysts Therefor, Patent #2,758,957 (K. Nozaki, assignor to Shell Development Co.) Process for the hydrogenation of aromatics and sulfur-bearing hydrocarbon oils which comprises contacting the aromatics and sulfur-bearing hydrocarbon oil under hydrogenation conditions of pressure above about 20 atmospheres and temperature between about 360 and 450° C. in the presence of added hydrogen with a supported nickel-molybdenum catalyst prepared by impregnating an alumina carrier with soluble compounds of nickel and molybdenum convertible to the oxides upon calcination, the mole ratio of nickel to molybdenum being between ¼ and ⅔ to 1 and the total metals content being above about 5% by weight, calcining to convert the metal compounds to the corresponding oxides, and partially sulfiding by treatment for at least ½ hour at a temperature below about 215° C. but above about 110° C. with mixture of hydrogen and hydrogen sulfide in a mole ratio between 1:1 and 40:1.

Blending Agents for Mineral Oils, Patent #2,758,971 (L. A. Mikeska, assignor to Esso Research & Engineering Co.) A lubricating oil composition containing dissolved therein in a range of about 0.01 to 15% by weight of the calcium salt of the partial ester of 1-hyydroxy-phosphonic acid.

Engine Preservative Oils, Patent #2,758,972 (W. H. Brugmann, Jr., L. E. Moody, & M. W. Hill, assignors to Esso Research & Engineering Co.) A composition of matter consisting essentially of a major proportion of a lubricating oil, from 0.5 to 1.0 wt. per cent of basic barium tert.-octyl phenol sulfide, 0.4 to 1.0 wt. per cent of basic calcium petroleum sulfonate, 0.4 to 1.0 wt. per cent of sodium petroleum sulfonate, and 0.3 to 2.0 wt. per cent of an aliphatic alcohol containing from 7 to 20 carbon atoms per molecule and a ratio of the number of carbon atoms in said alcohol to the weight per cent concentration of said alcohol in the range of about 9 to 20.

Process for Preparing Lubricating Grease Compositions, Patent #2,758,973 (A. J. Morway & T. E. Witts, assignors to Esso Research & Engineering Co.) The process for preparing a channeling-type high-temperature anti-friction bearing lubricant which comprises the steps of admixing with a mineral lubricating oil a grease forming amount of a complex soap, heating to a temperature sufficient to completely dissolve said soap, cooling the mixture to a temperature below the transition point of the soap, then adding a quantity of a synthetic lubricating oil sufficient to result in a mixture containing from about 6% to 18% soap, and subjecting the resulting mixture to the action of high rates of shear in the order of 10,000 to 500,000 reciprocal seconds under streamlined conditions to obtain a finished grease having an ASTM penetration value between 200 and 350 mm./10.

Synergistic EP Additive: A Mixture of Mercaptobenzothiazole & an Arylidene Amine, Patent #2,758,974 (R. B. Tierney, assignor to The Texas Co.) A

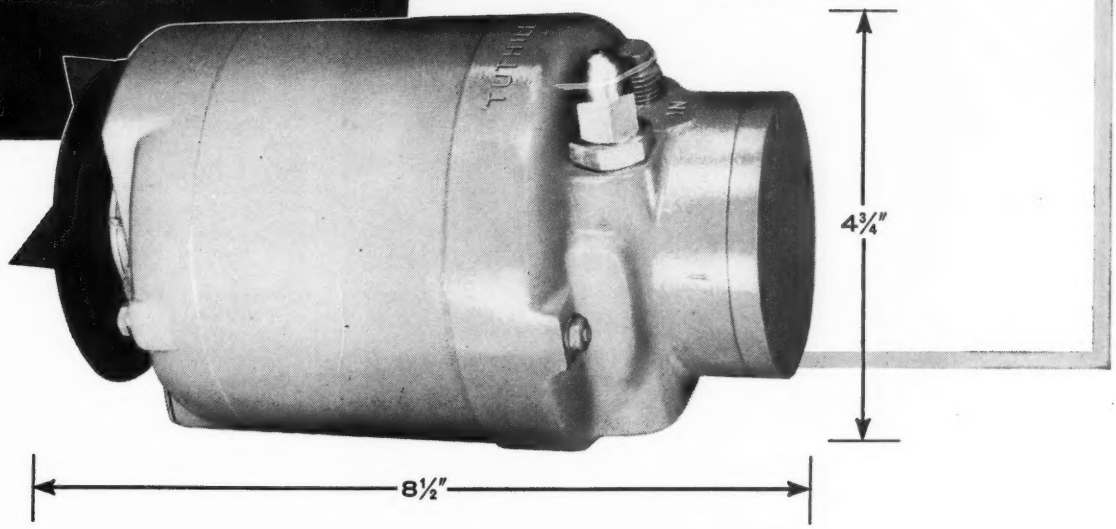
(Continued on p. 296)

ANOTHER PUMP PROBLEM...SOLVED BY **TUTHILL**

new POWERMITE

PUMP and MOTOR COMBINATION for LUBRICATION APPLICATIONS

• COMPACT • LIGHTWEIGHT
• ECONOMICAL



Here's another example of Tuthill's ability to develop the pump to fit the problem. Through years of experience in providing lubrication pumps for the country's leading original equipment manufacturers, we've constantly met the need to make the lubrication pump and its driving motor more compact in order to fit them into cramped spaces. Sometimes weight, too, is important. Every ounce that can possibly be saved pays off.

This compact, new Powermite motor-pump combination, a Tuthill exclusive, has been developed for these exacting lubrication applications. Motor and cooling blower have, in effect, been incorporated into the internal gear positive displacement rotary pump. The whole unit takes up no more space than a standard electric motor. A single shaft serves all units of the Powermite—and the elimination of couplings, other parts and labor permit substantial economies for OEM applications.

The pump section contains a built-in strainer, and, if desired, an adjustable relief valve. Powermite can be furnished with cooling blower, as illustrated, or it may be supplied with a shaft extension for driving other accessories.

Powermite can be furnished in a wide variety of pump and motor combinations. For example, the model illustrated has a capacity of 18 gallons per hour at 300 psi and is driven by a 1/12 hp motor at a speed of 1750 rpm.

Manufacturers desiring to investigate the cost, space and weight-saving advantages of incorporating Powermites into their products, are invited to submit detailed specifications. Or, if preferred, a Tuthill representative will call.

TUTHILL PUMP COMPANY
971 East 95th Street, Chicago 19, Illinois
Gentlemen:
☐ Please have your representative call to discuss Powermite applications in my product
☐ Please send catalog describing complete Tuthill line.
NAME_____ TITLE_____
COMPANY_____
STREET_____
CITY_____ STATE_____

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities from 1 to 200 GPM, for Pressures to 600 PSI, Speeds to 3600 RPM.

TUTHILL PUMP COMPANY

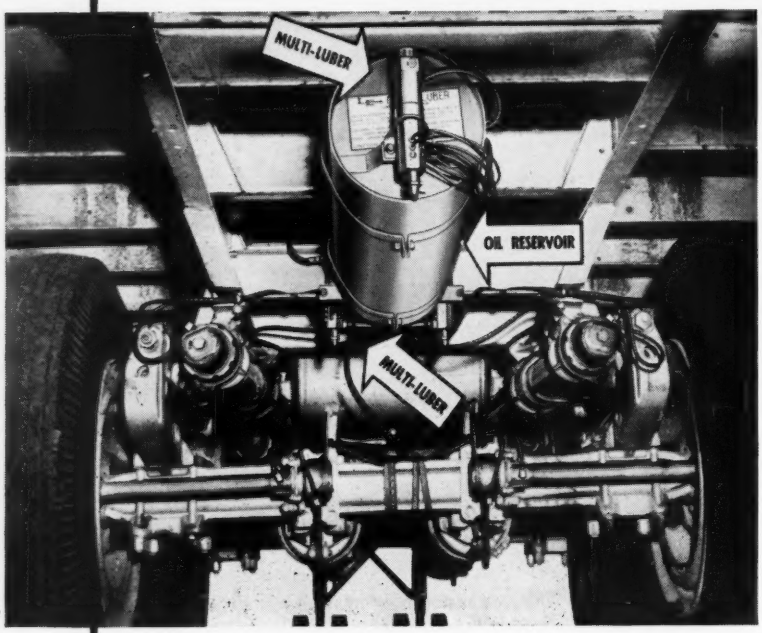
971 East 95th Street, Chicago 19, Illinois
Canadian Affiliate:
Ingersoll Machine & Tool Company, Ltd., Ingersoll, Ontario, Canada

PUMPS FOR YOUR PURPOSE

Lincoln FLEET *Multi-Luber

AUTOMATIC POWER LUBRICATION

Slashes operating and maintenance costs



Air-operated Multi-Luber units mounted on 7-gallon lubricant reservoir, as seen from rear of Freuhauf trailer. Feed lines supply lubricant to axle hanger, bracket assemblies, brake cams and slack adjusters.

Lincoln's Multi-Luber system *automatically* lubricates truck-trailers while they operate... doubles or triples the time interval between overhauls... and increases net profit per ton mile. Every time brakes are applied, the system cycles, forcing a measured quantity of refinery pure lubricant under high pressure into each bearing.

More than 500 over-the-road fleets are now using Lincoln Multi-Luber. Hundreds of thousands of test miles prove Multi-Luber provides maximum protection against bearing wear... smoother vehicle operation... elimination of down-time and man-hours for lubrication... increased service-life of bearings and moving parts. In fact, the six largest builders of truck-trailers have adopted Lincoln Multi-Luber as a factory-approved, optional accessory!

For complete information, write for Bulletin 532.

Lincoln

THE MOST TRUSTWORTHY NAME IN LUBRICATING EQUIPMENT

*Trade Name Registered

LINCOLN ENGINEERING COMPANY
Division of The McNeil Machine & Engineering Co.
5743 Natural Bridge Ave. • St. Louis 20, Mo.

Cover Story

Testing a High-Speed Bearing. The photograph on the front cover of this issue shows H. N. Kaufman, of the Bearings & Lubrication Section of Westinghouse Research Labs., carrying out tests on a high-speed bearing of the type used on Navy equipment. Performance data is recorded on special instruments built into this test apparatus. Oil film thickness and friction are measured under controlled conditions of speed, load, and temperature. The data obtained is applied to the improvement in design of bearings. (Submitted by Westinghouse Research Labs.)

(New Products, from p. 259)

After original assembly lubrication, additional application normally is not necessary in pneumatic systems. The new product, packaged in 4-ounce tubes, is described in *Sealer-Lube Catalog No. 5840, Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.*

2-Heat Flash Testers

The *Pensky-Martens Flash Testers* have been redesigned and are now offered in both electrically-heated and gas-heated models. Made for accurate, efficient determinations of flash points of fuel oils, crude petroleum, lubricating oils, gas oils, cutback asphalts, and animal, vegetable, and marine fats and oils flashing in the 130-450° F. range, the testers are also suitable for testing many similar products. The testers conform with specifications of the ASTM, AOCS, U. S. Government, and British Institute of Petroleum Technologists.

Stepless heat control is a feature of both flash testers, achieved in the electric model by use of an autotransformer with a calibrated reference dial, and in the gas model by an adjustable

Meker-type burner. A mechanized test flame injection apparatus provides simple, foolproof introduction of the flame into the test cup. Both test flame and pilot burner are adjustable. Sturdily constructed throughout, the tester is equipped with a sample cup cast in one piece. A stirrer shaft with double propellers agitates the liquid during the test. *For more information, write: Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Illinois.*

Universal Cartridge Filter Shell

A new type filter shell for lubricants and coolants which permits the use of any size or type filter media is now being produced. The necessity of shell replacement and repiping is eliminated when changing from one type filter cartridge to another. This is achieved with a specially-designed removable cartridge holder which can house any filter cartridge now in use, and can be designed for any type developed in the future. The ease in removing and installing the holders drastically reduces down-time when a spare holder is used as a standby. The shell is designed in all sizes for 125 psi ASME code construction, inspected and labelled, and can be used for flow rates of 20 to 900 gpm., capable of handling viscosities from 32 to 900 SSU, patent pending. *For more details, write: Alpha Tank Co., 1850 Steinway St., Long Island City, New York.*

Dipstick Heater

Economy and extreme ease of installation and operation are features of the recently-announced *Zero-Start* oil immersion (dipstick) engine preheater. The only unit of its type on the market, it fits any dipstick hole diameter of 5/16" or greater, and comes in two lengths of 13 and 20 inches. Shank of the heater is copper coated, double thickness Bundyweld steel tubing. A 3-foot water-tight rubber cord is permanently attached by a special patented moisture-proof and wear-resistant crimping.

Using a cartridge-type nickel-chrome-resistant wire element, the dipstick heater is rated at 100 watts and is designed to begin all-night operation while the motor and oil are still warm. Substantial savings in operating costs are evident considering that a normal night's use takes about one kilowatt of power costing only a few cents.

An interesting sidelight is that, by some electrolytic action, it attracts carbon particles from the oil. If wiped regularly, as per instructions on the carton, the unit will assist in keeping the oil carbon-free. Extensive testing has shown that shock hazard, caused by current leakage, is almost non-existant. Each unit is factory tested and fully guaranteed. *Phillips Mfg. Co., Inc., 2816 Aldrich Ave. S., Minneapolis 8, Minnesota.*

Pressure Transducer

A new, small, low-cost pressure transducer for both airborne and ground applications has been announced that is designed for reliable and accurate service with a wide variety of fluids, including all jet and piston engine fuels, lubricating and hydraulic oils, and air, carbon dioxide and oxygen. Output signals may be either linear or to any desired curve, as required for actuating the appropriate control or measuring system.

The transducer will normally be available in pressure ranges of from 0-2 psi to 0-250 psi, although other ranges can be supplied as required. It will be offered with potentiometer cards in resistance ranges of from 0-2000 ohms to 0-20,000 ohms. Current rating of a typical potentiometer is 10 ma. at 5200 ohms, although other requirements can be handled. Models with resolution of better than 0.1% are available.

Fitted with standard 3-pin connector plug terminals, and ⅛" ANPT or 7/16" — 20 NF3 pressure fittings, the units are hermetically sealed; all materials have been selected for galvanic similarity. Over-all length is 2-7/16", diameter is 2⅞", weight is 6 ounces. *For additional details and prices, write: Bristol Co., Waterbury 20, Connecticut.*

(Lube Abstracts, from p. 290)

A, B, and *x* are constants. A fundamental viscosity-temperature index is defined by the quantity log ($\nu 20/\nu 70$), based on this formula. A number of hydrogenated mineral oil fractions of well-known composition were examined and found to show a relationship between the fundamental viscosity-temperature index, the refractive index, and total naphthene ring content. (*Abstracter: E. S. Francis*)

American Society of Lubrication Engineers
Founded 1945
Chicago Illinois

This certifies that

John Doe

is a

Member

of this Society organized to promote the science and practice of lubrication and for acquiring and perpetuating that knowledge necessary to the lubrication engineer.

Administrative Secretary President

NOW AVAILABLE Restyled 8-½ x 11"

ASLE Membership Certificates

With name hand-lettered, and showing date of admission $1.50
Same as above, but suitably framed, ready for hanging $4.50

To order, indicate your preference; include your name and address, enclose remittance, and mail to:

ASLE, 84 E. Randolph St., Chicago 1, Ill.

(Coming Events, from p. 265)
erating Engineers (53rd Annual Meeting), Hotel Fontainbleau, Miami Beach, Fla.

3-7, American Society of Civil Engineers (National Convention), Statler Hotel, Buffalo, N. Y.

6-8, National Society of Professional Engineers (Annual Meeting), Statler-Hilton Hotel, Dallas, Tex.

9-12, American Institute of Chemical Engineers (Regional Meeting), Olympic Hotel, Seattle, Wash.

9-13, American Society of Mechanical Engineers (Semi-Annual Meeting), Sheraton-Palace Hotel, San Francisco, Calif.

9-14, Pennsylvania State University Automation Seminar, Penn. State Univ., University Park, Pa.

10-12, American Nuclear Society (3rd Annual Meeting), Penn Sheraton Hotel, Pittsburgh, Pa.

11-13, 1957 Western Plant Maintenance & Engineering Show, Civic Auditorium, San Francisco, Calif.

12-14, Operations Research Conference, Illinois Institute of Technology Campus, Chicago, Ill.

13-14, Illuminating Engineering Society (Northeastern Regional Conference), Statler Hotel, New York City.

13-15, American Society of Mechanical Engineers (Applied Mechanics Conference), Univ. of Calif., Berkeley, Calif.

OCTOBER 7-9, ASLE-ASME 4th Annual Lubrication Conference, Royal York Hotel, Toronto, Canada.

(Book Reviews, from p. 257)
index. More than 1,000 authors have contributed over 800 articles, and it has been brought to its full usefulness with the publication of the final volume consisting mostly of the Index: a 620-page compilation of approximately 50,000 entries bearing on the entire work.

A Supplement Volume, to be published in late '57, already is in preparation. This will deal with certain subjects in which technical developments have been unusually striking, and will present the new knowledge in a format similar to the original volumes. (Note: The subscription price for the 15-volume work will be increased to $400.00 on July 1, 1957; the Supplement Volume will be $25.00.)

(Patent Abstracts, from p. 292)
lubricant composition consisting essentially of an oleaginous liquid containing a corrosion-inhibiting amount of phenothiazine and 0.05-1.5% by weight of a mixture in a 1:2-4:1 mol ratio of a compound selected from the class consisting of mercaptobenzothiazole and its homologs containing at least one aliphatic hydrocarbon radical substituted on the benzol nucleus and a disalicylal alkylene diamine wherein the alkylene group is a C_{2-6} alkylene group and the amine groups are attached to different carbon atoms thereof.

Synthetic Lubricants, Patent #2,758,975 (D. L. Cottle, F. Knoth, Jr., & D. W. Young, assignors to Esso Research & Engineering Co.) A synthetic lubricating composition which comprises a major proportion of a mixture of organic carbonates of the formula RO—CO—OR′ wherein R and R′ are branched chain alkyl groups derived from C_{10} to C_{20} alcohols, containing combined therein a minor but extreme pressure-improving amount of tricresyl phosphate, said mixture of organic carbonates having a pour point below about −20° F. and a flash point above about 300° F., said alcohols being predominantly isomeric mixtures of branched-chain saturated aliphatic primary alcohols.

Non-Flammable Hydraulic Fluid, Patent #2, 758,976 (G. E. Barker, assignor to Atlas Powder Co.) A hydraulic fluid composition exhibiting a viscosity-temperature slope of not more than 0.49 on Chart E of the American Society for Testing Materials Specification D341 and consisting essentially of a solution of from 10% to 30% by weight of the condensation product of 28 molar proportions of ethylene oxide with one molar proportion of a dimerized, 18-carbon, polyunsaturated fatty acid in an aqueous ethylene glycol containing from 50% to 70% by weight of ethylene glycol and correspondingly from 50% to 30% by weight of water.

Corrosion-Preventive Composition, Patent #2,758,981 (H. H. Cooke & H. C. DeHoff, assignors to Esso Research & Engineering Co.) A substantially anhydrous corrosion-preventive composition consisting essentially of a mineral lubricant-base stock thickened to a semi-solid, grease-like consistency with a calcium soap of hydrogenated fish oil fatty acids having in the range of about 14 to 24 carbon atoms, said soap being present in an amount in the range of about 5 to 45% by weight, calcium hydroxide dispersed throughout said composition as a finely divided solid in an amount in the range of about 10 to 20% by weight, in the range of 0.1 to 10% by weight of a polymer of isobutylene having a molecular weight of about 10,000 to 60,000, and in the range of 0.5 to 15% of a microcrystalline paraffin wax.

Extreme-Pressure Lubricant, Patent #2,759,893 (H. S. Beretvas, assignor to Standard Oil Co.) A normally liquid extreme-pressure lubricant comprising a lubricating oil and a minor amount of a complex lead soap of naphthenic acid

NEW...
EMERY 3033-S LUBRICANT ESTER...

a new-type diester base for synthetic lubricants

Emery 3033-S is a new-type dipropylene glycol diester based on pelargonic acid, a unique, C_9, saturated, monobasic acid.

It is currently in use or under test in the following three areas: 1) Synthetic greases for spec. Mil-G-3278-A Low Temperature Aircraft Grease; 2) Low-cost blending component for synthetic low-temperature lubricating fluids meeting Mil-L-7808 C; and 3) synthetic lubricant base fluid for civilian lubricants in aircraft, automotive and specialty uses.

Since 3033-S is based on a relatively low-cost acid, pelargonic acid, long-range economics are favorable. Also, availability is not contingent on strategic, imported raw materials since pelargonic acid is made from abundantly available domestic fats and oils.

Though 3033-S is in a development stage, it is available in tankcar quantities on reasonable notice.

Mail coupon below for Technical Bulletin titled "Emery 3033-S Lubricant Ester" for complete characteristics and performance data in synthetic greases and fluids.

Emery

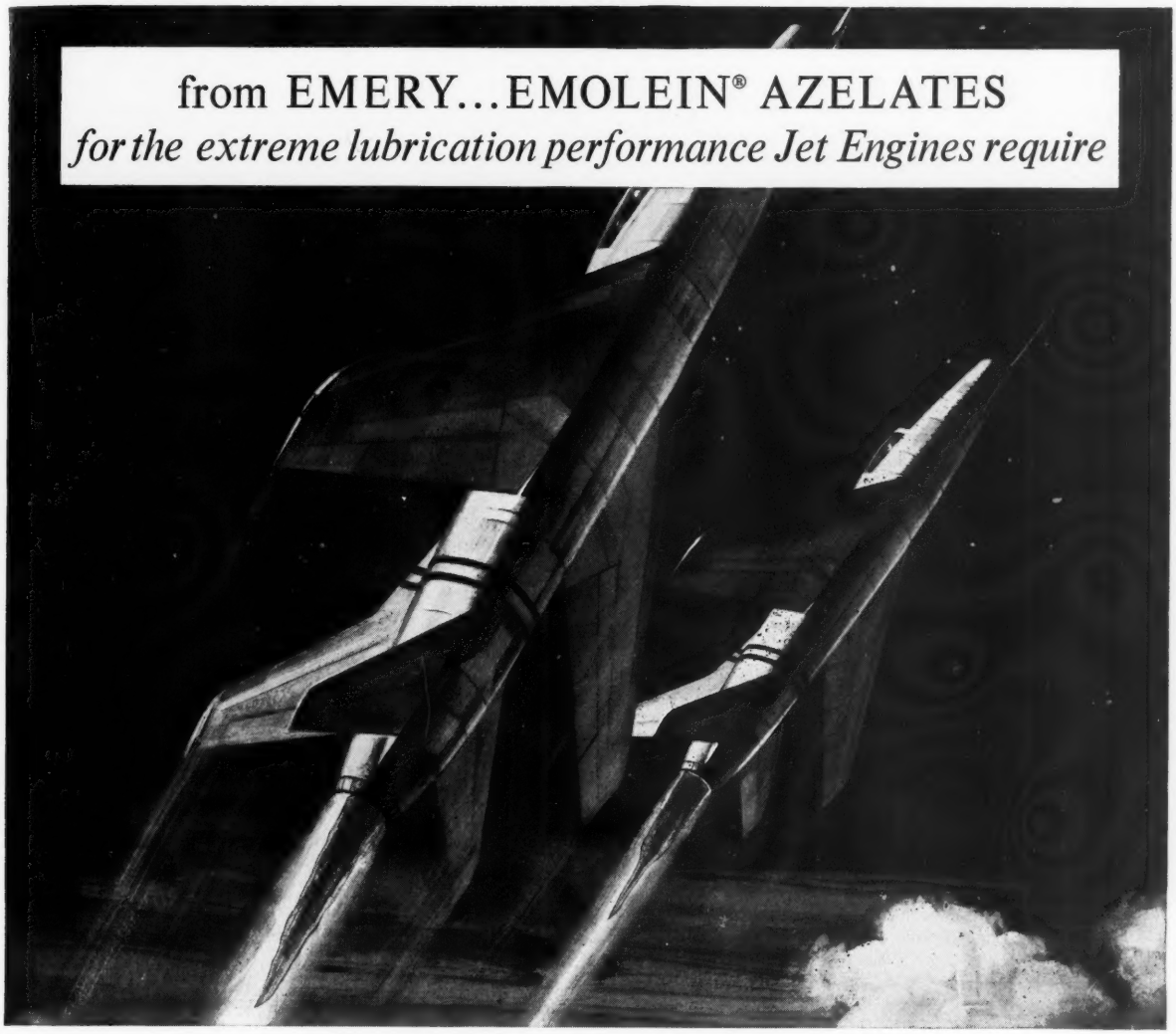
Development and Service Department
Emery Industries, Inc.
Carew Tower, Cincinnati 2, Ohio

Emery Industries, Inc.
Dept. LE-5A, Carew Tower
Cincinnati 2, Ohio

Please send Development Product Bulletin #60 on Emery 3033-S.

Name.....
Company.....
Address.....
City.....State.....

from EMERY...EMOLEIN® AZELATES
for the extreme lubrication performance Jet Engines require



MEETS BOTH MILITARY AND CIVILIAN REQUIREMENTS

Synthetic lubricant fluids that meet both military (Mil-L-7808-C) and civilian specifications are now being compounded from Emolein Azelates (diesters).

The excellent performance of these new diesters, Emolein 2957 di-iso-octyl azelate and 2958 di-2-ethylhexyl azelate in lubricants designed to meet the extreme heat and cold performance qualities required by jet engines, is attributed to the following combination of properties:

1) excellent temperature-viscosity performance even at high and low temperature extremes... 2) high viscosity index... 3) low pour points... 4) excellent lubricity... 5) oxidation and corrosion stability... 6) high flash and fire points... 7) excellent additive response.

Produced from non-strategic raw materials

Since the Emolein azelates are based on azelaic acid obtained from domestic fats and oils abundant in supply, availability is not contingent on strategic imported raw materials. Also, future plant expansion is being carefully coordinated with the broadening utility of these diesters.

Application in other synthetic lubricants

Other military specifications met by synthetic fluids and greases compounded from Emolein Azelates include: Mil-G-3278 A, Grease, Aircraft and Instruments-Low and High Temperatures; Mil-L-6085 A, Lubricating Oil, Aircraft Instruments, Low Volatility; and Mil-L-6387 A, Lubricating Oil, Synthetic Base.

Mail coupon below for full technical information.

Emery **Organic Chemical Sales Department**

Emery Industries, Inc., Carew Tower, Cincinnati 2, Ohio

Emery Industries, Inc., Dept. LE-5, Carew Tower Cincinnati 2, Ohio

Please send me a copy of your 16-page Technical Bulletin No. 409 titled "Emolein Esters for Synthetic Lubricants."

Name.....Title.....

Company.....

Address.....

City.....State.....

ASLE MEMBERSHIP CLASSIFICATIONS

Membership in the American Society of Lubrication Engineers is in several grades as defined below. Assignment to grade is made by the Admissions Committee or Board of Directors on the basis of information submitted or supplied by references.

Members: Members shall be persons not less than 24 years of age who: (1) are engaged in research and instruction at technical schools, universities, and various publicly and privately supported institutions in the field of lubrication; or (2) have occupied recognized positions as lubrication engineers for a period of three or more (not necessarily consecutive) years prior to date of admission, involving the responsibilty for or supervision of the development, selection, field use and application of lubricants as differentiated from other activities; or (3) are indirectly concerned with the field of lubrication, but possessing other qualifications of experience, knowledge, and accomplishment, and have manifested a particular interest in the purposes and welfare of the Society to the extent that their membership would be a valuable contribution to the successful functioning of its activities. Fee $15.00.

Associate Members: Associate Members shall be persons less than 24 years of age, and those who do not completely fulfill the membership requirements for Members. Fee $7.50.

Sectional Sustaining Members: Sectional Sustaining Members are such persons or organizations as may be interested in and desire to contribute to the support of the purposes and activities of a local Section of the Society. Fee $25.00.

Industrial Members: Industrial Members are such persons or organizations as may be interested in and desire to contribute to supporting the purposes and activities of the Society. Fee $150.00.

For application blanks or further information, write:

ASLE
84 E. Randolph St.
Chicago 1, Ill.

and an hydroxy aromatic carboxylic acid, the aromatic nucleus of which contains not more than 10 carbon atoms, said nucleus having attached thereto a carboxyl group and attached to said aromatic nucleus at least one hydroxyl group, said complex lead soap being prepared by heating a mixture of from about two parts to five parts by weight of lead naphthenate per part by weight of litharge in the presence of from about 1.5 mols to about 2.5 mols of an hydroxy aromatic carboxylic acid per mol of litharge in said mixture.

Rust Inhibitor, Patent #2,759,894 (A. H. Matuszak, assignor to Esso Research & Engineering Co.) A composition consisting essentially of a mineral lubricating oil containing dissolved therein 0.1% to 10% of the oil-soluble product formed by reacting about equal molecular proportions of oleyl chloride and trimethylol amino methane at about 50-60° C. in the presence of a sufficient amount of pyridine to absorb one molecular proportion of hydrogen chloride for each molecular proportion of oleyl chloride reactant, for a period of at least 15 minutes, and removing the pyridine and pyridine hydrochloride formed in the reaction from the reaction product.

Preparation of Phosphorus Sulfide-Hydrocarbon Reaction Products, Patent #2,759,920 (R. W. Watson & M. Fainman, assignors to Standard Oil Co.) In the preparation of an oil- soluble lubricant addition agent wherein a normally liquid hydrocarbon is reacted with about 1% to about 50% of a phosphorus sulfide at a temperature of from about 200 to about 600° F. and the resultant reaction product hydrolyzed at a temperature of from about 220 to about 500° F., whereby inorganic acids of phosphorus are formed, the improvement comprising contacting said hydrolyzed reaction product at a temperature of from about 100 to about 500° F. with a basic alkaline earth compound selected from the group consisting of an oxide, hydroxide and carbonate of calcium, barium and strontium in an amount sufficient to precipitate substantially only said alkaline earth salts of the inorganic acids of phosphorus formed by said hydrolysis, and removing said precipitated salts, whereby an oil-soluble reaction product of a phosphorus sulfide and a hydrocarbon substantially free of inorganic acids of phosphorus is obtained.

Drawing Compound, Patent #2,760,931 (S. Spring & W. A. Blum, assignors to The Pennsylvania Salt Mfg. Co.) A lubricant composition in the form of an emulsion comprising 1 to 5 parts water-dispersible fatty acid soap, 5 to 12 parts fat, 0.5 to 2 parts of expanded starch, and 80 to 92 parts water, said starch having been expanded by heating in water for at least one hour at a temperature of at least 150° F.

Lubricant, Patent #2,760,932 (E. K. Fields & R. W. Watson, assignors to Standard Oil Co.) A composition comprising the substantially olefin-free reaction product obtained by reacting at a temperature in the range of from about 200 to about 450° F. a phosphorus sulfide with a fraction boiling in in the range of from about 200 to about 650° F. of the hydrocarbon phase of the liquid product resulting from the catalytic reduction of carbon monoxide with hydrogen at elevated temperatures and pressures, said fraction comprising at least about 60% hydrocarbons and a substantial amount of oxygenated compounds.

Lubricants, Patent #2,760,933 (E. K. Fields & C. S. Scanley, assignors to Standard Oil Co.) A composition comprising a major proportion of an oleaginous material containing a compound, normally corrosive to silver, selected from the group consisting of elemental sulfur, a sulfur-containing organic compound and mixtures thereof, and from about 0.02% to about 15% of a carboxylic ester of 2,5-dimercapto-1,3,4-thiadiazole.

Lubricant Compositions, Patent #2,760,935 (J. D. Klicker & D. R. Stevens, assignors to Gulf Research & Development Co.) A lubricant composition comprising a major amount of a lubricating oil and a minor amount sufficient to improve the detergency characteristics thereof of a metal salt of a naphthenoyloxypropionic acid.

Manufacture of Lithium Grease, Patent #2,760,936 (P. J. Baker, assignor, by mesne assignments, to National Cylinder Gas Co.) The process of preparing lithium grease comprising forming a slurry of lithium stearate and mineral oil containing substantially all the lithium stearate and approximately half the oil desired in the finished grease, raising the temperature of the slurry to a temperature consistent with complete solution of the lithium stearate in the oil and above about 400° F. to completely dissolve the lithium stearate in the oil and form a homogeneous solution free from undissolved lithium stearate particles by passing the slurry in a thin layer under agitation in contact with a heat transfer wall, continuously mixing the remainder of the oil desired in the finished grease with the hot solution under conditions conducive to mixing with a minimum of shear to provide intimate mixing without micelle disruption, the added oil having a temperature such as to produce a resultant temperature of the mixed oil and solution within the range from about 230 to 310° F., passing the resultant mixture through a cooling zone under conditions of agitation to reduce the temperature thereof below 160° F., and finally milling the product for a sufficient time at a temperature below 160° F. to eliminate syneresis and produce stability in the finished grease.

Phosphorus-Contalning Lubricant Additives, Patent #2,760,937 (J. P. McDermott, assignor to Esso Research & Engineering Co.) A lubricant composition comprising a major proportion of a mineral lubricating oil having a viscosity in the range of about 35 to 150 SSU at 210° F. and about 0.01 to 20.0% by weight.

High-Temperature Lubricating Compositions, Patent #2,761,844 (C. D. Ackerman, P. R. McCarthy & T. R. Orem, assignors to Gulf Research & Development Co.) A lubricating composition consisting of a uniform mixture of about 20 to about 40 per cent by weight of powdered graphite, about 5 to about 20 per cent by weight of dimethyldicetyl ammonium bentonite, and about 50 to about 70 per cent by weight of di-2-ethylhexyl sebacate.

Foam Inhibition of Oils, Patent #2,761,845 (D. T. Rogers & J. P. McDermott, assignors to Esso Research & Engineering Co.) The process of substantially reducing the foam-promoting tendency in a lubricating oil composition of an oil-soluble detergent additive selected from the group consisting of metal sulfonates, metal alkyl phenol sulfides, phosphosulfurized metal alkyl phenol sulfides and mixtures thereof, which comprises adding about 0.1 to 50% by weight, based on the additive, of an aliphatic alcohol of the C_1 to C_5 range to an oil solution containing said additive and blowing said oil solution with an inert gas at an elevated temperature until essentially all of said alcohol is removed therefrom.

Mineral Oil Compositions, Patent #2,762,773 (J. F. Palmer, Jr., assignor to Monsanto Chemical Co.) A lubricating composition comprising a mineral oil fraction of lubricating viscosity having dissolved therein (a) 0.1 to 10% by weight based on the mineral oil of the oil-soluble product obtained by reacting in substantially equimolecular proportions carbon dioxide and a barium 2,4-dialkyl phenate wherein the alkyl substituents contain from 5 to 10 carbon atoms and (b) 0.1 to 10% by weight based on the mineral oil of the oil-soluble product obtained by reacting substantially one molecular proportion of carbon dioxide with substantially two chemical equivalents of a basic barium salt of a long chain alkyl substituted aryl sulfonic acid, the said long chain alkyl substituents containing at least 8 carbon atoms.

Pour Depressant-Detergent Additive Combination, Patent #2,762,774 (A. H. Popkin, assignor to Esso Research & Engineering Co.) A mineral lubricating oil of improved pour and detergency characteristics having combined therewith in the range of 0.01 to 0.1 by weight of a pour-point depressing polymeric material selected from the group consisting of polymers of a methacrylate ester, copolymers of a maleate ester and a vinyl compound and copolymers of a fumarate ester and a vinyl compound, said ester portions containing in the range of 8 to 18 carbon atoms, and said vinyl compounds having in the range of 4 to 20 carbon atoms, and in the range of about 0.2 to 5.0% by weight of a carbon dioxide-treated oil-soluble alkaline earth metal salt of a phenolic compound, the weight ratio of said polymeric material to said treated metal salt being below about 0.06:1.0, said salt having been treated with carbon dioxide until an appreciable amount of carbon dioxide has been absorbed.

Wax and Polyethylene for Filter Adhesives, Patent #2,762,775 (E. G. Foehr, assignor to California Research Corp.) A filter adhesive composition comprising a major proportion of a hydrocarbon oil and from 4% to 6%, by weight, of a mixture of wax and polyethylene, wherein the mole ratio of wax to polyethylene has a value from 2 to 5, said wax having a melting point in the range of 90 to 140° C., and said polyethylene having a molecular weight in the range of 10,000 to 40,000.

Lubricating Oil Containing Dicyclopentadienyl Iron & an Oil-Soluble Organic Divalent Metal Salt, Patent #2,763,613 (L. B. Scott, A. C. Nixon & D. G. Roddick, assignors to Shell Development Co.) A lubricating oil composition comprising a predominant amount of a lubricating oil and a minor, but effective knock-reducing amount of a dicyclopentadienyl iron compound containing only iron, carbon and hydrogen in the molecule, and a minor, but effective, wear-inhibiting amount of an oil-soluble divalent metal salt of an organic acidic compound selected from the group consisting of divalent metal sulfonates, divalent metal phenates, divalent metal phosphates and divalent metal carboxylates.

Corrosion-Inhibiting Compositions, Patent #2,763,614 (T. L. Cantrell & E. E. Fisher, assignors to Gulf Oil Corp.) A bright, stable corrosion-inhibiting composition comprising about 49 to about 88 per cent by weight of the composition of a mineral oil base, and having incorporated therein from about 5 to about 15 per cent by weight

ASLE Preprints Available

A limited supply of the following preprints of papers presented at the ASLE-ASME 1956 Lubrication Conference are still available at 35c each to members, 50c each to non-members. To order, indicate the number of copies desired, fill in your name and address, enclose remittance, and mail to:

ASLE, 84 E. Randolph St., Chicago 1, Ill.

_____(56LC-7) *Application of Reaction Rate Theory to the Weld Junction Aspect of Kinetic Friction Between Unlubricated Metallic Surfaces,* by F. F. Ling & E. Saible

_____(56LC-1) *Application Problems with Petroleum Lubricants in Nuclear Power Plants,* by R. F. Hausman & E. R. Booser

_____(56LC-5) *Effects of Nuclear Radiation on Lubricants,* by J. A. King & W. L. R. Rice

_____(56LC-9) *Fretting of Hardened Steel in Oil,* by J. R. McDowell

_____(56LC-6) *Fundamental Study of Synthetic Sapphire as a Bearing Material, A,* by L. F. Coffin, Jr.

_____(56LC-2) *General Radiation Damage Problems for Lubricant & Bearing-Type Materials,* by V. P. Calkins & C. G. Collins

_____(56LC-18) *Influence of Temperature on Boundary Lubrication,* by C. W. Cowley, D. J. Ultee & C. W. West

_____(56LC-13) *Investigation of "Melt Lubrication,"* by B. Sternlicht & H. Apkarian

_____(56LC-10) *PbO & Other Metal Oxides as Solid Lubricants for Temperatures to 1000° F.,* by M. B. Peterson & R. L. Johnson

_____(56LC-4) *Radiation-Resistant Greases,* by J. G. Carroll, R. O. Bolt & B. W. Hotten

_____(56LC-8) *Solid Film Lubricant—Factors Influencing Their Mechanism of Friction & Wear,* by R. E. Crump

_____(56LC-12) *Solution for the Finite Journal Bearing & Its Application to Analysis & Design — II, A,* by A. A. Raimondi & J. Boyd

_____(56LC-16) *Specific Heat at Low Temperatures and Latent Heat of Fusion of Aircraft Engine Lubricants,* by V. E. Shrock & R. E. Gott

_____(56LC-11) *Temperature Effects in Journal Bearing Lubrication,* by W. F. Hughes & J. F. Osterle

_____(56LC-17) *Thermal Conductivity & Thermal Diffusivity of Aircraft Engine Lubricants at Low Temperatures,* by V. E. Schrock & E. S. Starkman

_____(56LC-3) *Use of Rolling Contact Bearings in Low Viscosity Liquid Metal Lubricants,* by W. Markert, Jr. & K. M. Ferguson

_____(56LC-14) *Yield Stress as a Factor in the Performance of Greases,* by D. Evans, J. F. Hutton & J. B. Matthews

Name_____

Address_____

City_____ Zone_____ State_____

of water, from about 0.25 to about 2.5 per cent by weight of an alkanol amine selected from the group consisting of primary, secondary and tertiary alkanol amines whose alkanol substituents contain from 2 to 3 carbon atoms, from about 0.1 to about 1.0 per cent by weight of a salt of a primary aliphatic amine containing from 8 to 18 carbon atoms and a dialkyl ester of orthophosphoric acid, the alkyl substituents of which contain from 3 to 10 carbon atoms, from about 1 to about 10 per cent by weight of an alkali metal salt of an oil-soluble sulfonic acid, from about 0.75 to about 7.5 per cent by weight of a fatty acid containing from 12 to 24 carbon atoms, the fatty acid: alkanol amine mol ratio being in excess of 1:1, a total of about 5 to about 15 per cent by weight of a coupling agent selected from the group consisting of 2-butoxyethanol and mixtures thereof with butanol, the 2-butoxyethanol being present in an amount of from about 1 to about 15 per cent by weight, and the butanol being present in an amount of from about 0 to about 14 per cent by weight.

Lubricating Oil Containing Dicyclopentadienyl Iron & A Wear-Inhibiting Agent, Patent #2,763,617 (L. B. Scott, A. C. Nixon & D. G. Roddick, assignors to Shell Development Co.) A lubricating oil composition comprising a predominant amount of a lubricating oil and a minor but effective knock-reducing amount of a dicyclopentadienyl iron compound containing only iron, carbon and hydrogen in the molecule, and a minor, but effective wear-inhibiting amount of an oil-soluble organic ester of an inorganic acid selected from the group consisting of trihydrocarbyl phosphates, trihydrocarbyl phosphites, trihydrocarbyl arsenates, trihydrocarbyl arsenites and trihydrocarbyl borates.

Steam Cylinder Lubricating Oil, Patent #2,764,529 (R. J. Leygonie & B. B. de Saint Leger, assignors to Esso Standard Societe Anonyme Francaise) A steam cylinder lubricating oil comprising a propane-deasphalted phenol treated Mid-Continent reduced crude containing combined therewith from 10% to 40% by volume of a high molecular weight paraffinic material obtained by treating an asphalt with from 10 to 12 volumes of a liquid mixture of butane and propane containing from 10% to 30% by volume of propane at a temperature within a range from 70 to 100° C. to obtain an extract containing both paraffinic and naphthenic components, extracting the extract thus obtained with anhydrous phenol, and obtaining therefrom said high molecular weight paraffinic material as a raffinate.

Corrosion Resistant Lubricant Composition, Patent #2,764,547 (E. K. Fields, assignor to Standard Oil Co.) A composition comprising a major proportion of an oil containing a compound normally corrosive to silver, selected from the group consisting of elemental sulfur, a sulfur-containing organic compound and mixtures thereof, and from about 0.02% to about 10% of the oil-soluble reaction product of 2,5-dimercapto-1,3,4-thiadiazole and an unsaturated cyclic hydrocarbon having at least one olefinic double bond and at least about six carbon atoms, said thiadiazole and said unsaturated cyclic hydrocarbon being reacted in the molar ratio of from 3:1 to 1:1 at a temperature of from about 25 to about 150° C.

Gear Oil Lubricants, Patent #2,764,550 (J. B. Stucker, N. D. Williams & G. Wolfram, assignors to The Pure Oil Co.) A lubricating composition comprising a major portion of a mineral lubricating oil containing as a part thereof lubricating oils selected from the group consisting of solvent-refined lubricating oil and Pennsylvania bright stock in an amount sufficient to cause incompatibility of sulfurized- phosphorized fatty bodies therewith, sufficient amount of a sulfurized-phosphorized fatty body to impart extreme-pressure characteristics thereto, and a sufficient amount of phenol extract obtained from the extraction of mineral lubricating oils for the purpose of separating paraffinic from non-paraffinic hydrocarbons therein to prevent separation of said sulfurized-phosphorized fatty body from said composition.

ASLE JEWELRY

The new ASLE jewelry is available in the form of tie clasps, lapel pins, or cuff links at $3.50, $1.50, and $4.50 each, respectively, from the National Office. Many of the Sections are using the jewelry in their membership campaigns. Details are available through the National Office.

(Summaries of Foreign Papers, from p. 278)

Compounds in group 1 tend to promote oxidation, whereas the additives in the other groups do not. (*Reviewer's Note: Detergents in group 3 actually possess oxidation-inhibiting properties.*) Detergents in group 4 have superior high-temperature stability.

CORROSION INHIBITORS & ANTI-FOAM AGENTS

Experimental data cited by the author indicate that sulfur-containing compounds and esters of phosphorous acid, such as tributyl phosphite and triphenyl phosphite, are effective in reducing corrosion of non-ferrous bearing metals. Among the anti-foam agents, silicone polymers (polymethyl siloxanes) are most effective. (*Reviewer's Note: It is interesting to notice that the author mentions the use of silicone in concentration up to 0.1% which seems to be quite high.*) (*Reviewed by I-Ming Feng*)

"Resin Formation in Oxidation of Hydrocarbons," by S. R. Sergienko & P. N. Galich, *Zhur. Priklad. Khim., Vol. 28*, 1955, pp. 669-705.

In order to control the direction and rate of hydrocarbon oxidation processes and their susceptibility to resin formation in motor fuels and lubricants, the liquid phase oxidation of various C_{11-13} hydrocarbons was investigated.

Oxygen was introduced for 100 hours at 150° and samples were removed at intervals for determination of peroxide, oxide, saponification and bromine numbers, elementary analysis, and resin content. The final reaction products were separated by solvent treatment and chromatography into carboids, asphaltenes, resins, low-molecular weight oxygen compounds, and unreacted hydrocarbons.

Oxidation of α-methyldecalin resulted in the formation of considerable quantities of low-molecular weight oxygen compounds and condensation products, resins, both ether-soluble and ether-insoluble asphaltenes, and carboids. The condensation products increased in molecular weight, acid and saponification number, carbon content, and C:H ratio in the order stated, while the bromine number declined. Pigmentation started only after a certain minimum of oxidation products had formed; at the same time the viscosity began to increase.

The results indicate that the oxidation of α-methyldecalin is accompanied by extensive cleavage. Its oxidation

ASLE Preprints Available

(from 12th Annual Meeting)

A limited supply of the following Preprints of papers presented at the ASLE 1957 Annual Meeting are available at 35c each to members, 50c each to non-members. To order, indicate the number of copies desired, fill in your name and address, enclose remittance, and mail to:

ASLE, 84 E. Randolph St., Chicago 1, Ill.

____(57AM-4A-2) *Apparent Adsorption Isotherms of Oleic Acid from Hydrocarbon Solution as Obtained from Coefficient of Friction Measurements,* by A. Miller & A. A. Anderson
____(57AM-5B-2) *Car Oil Additives,* by L. C. Atchison
____(57AM-5A-5) *Chemical Additives for Hypoid Gears,* by C. V. Smalheer
____(57AM-4A-1) *Chemical Nature of Extreme-Pressure Lubrication, The,* by G. Hugel
____(57AM-2A-1) *Choose Your Press Drawing Lubricants with Care,* by L. Salz
____(57AM-6A-4) *Circulating Oil Systems from 1/50 to 50 GPM,* by E. W. Baumgardner
____(57AM-6A-2) *Considerations in Filter Selection,* by H. A. Wilson
____(57AM-2A-2) *Conversion Coatings Aid the Lubrication of Titanium,* by E. L. White & P. D. Miller
____(57AM-4C-2) *Design & Operation of Ball Bearings for Use in Pressurized Water Systems,* by P. R. Eklund
____(57AM-5A-4) *Development of New Automotive Gear Lubricants,* by T. P. Sands
____(57AM-4A-5) *Dislocation Theory Approach to Boundary Lubrication, Thin-Film Bearings & Wear-In, A,* by J. H. Dismant
____(57AM-4C-4) *Dynamic Oxidation Tester to Evaluate Grease or Ball-Bearing Performance at High Temperatures, A,* by H. E. Mahncke & D. J. Boes
____(57AM-3B-1) *Effect of Additives on Crankcase-Oil Filterability,* by E. C. Ballard & R. L. Willis
____(57AM-2B-2) *Effect of Bearing Deformation in Slider-Bearing Lubrication, The,* by F. Osterle & E. Saibel
____(57AM-4B-3) *Establishing Lubrication Practices in an Automated Engine Plant,* by D. F. Miller
____(57AM-2A-3) *Evaluation of Cutting Fluid Performance,* by H. W. Husa & W. L. Bulkley
____(57AM-3B-2) *Field Study of Gas-Engine Lubricants, A,* by C. M. Floyd
____(57AM-6A-1) *Filtration of Brass Mill Coolants,* by G. Signor
____(57AM-6A-3) *Filtration of Railroad Diesel Engine Oils,* by W. K. Simpson
____(57AM-5B-1) *Friction & Oil-Feed Characteristics of Journal Box Packing,* by W. M. Keller & G. L. Pigman
____(57AM-1A-2) *Frictional Properties of High-Temperature Seal Materials,* by J. F. Cerness, D. H. Strong & K. Pilarczyk
____(57AM-4C-1) *Grease Lubrication of Ultra-High-Speed Rolling Contact Bearings,* by J. B. Accinelli
____(57AM-4B-2) *Increased Machine Productivity Demands Well-Designed Lubrication Practices,* by R. H. Guy
____(57AM-3C-3) *Is Boundary Lubrication a Myth?* by W. Lewicki
____(57AM-3A-3) *Lubrication in a Chemical Plant,* by R. W. Clark
____(57AM-3A-2) *Lubrication in a Glass Container Manufacturing Plant,* by D. E. Grube
____(57AM-3A-1) *Lubrication Standards for Industrial Equipment,* by S. O. Kimball
____(57AM-4C-3) *Mass Data Study of Separator Effect on the Starting Torque of R4D Bearings,* by J. C. Lawrence, R. V. Milligan & P. E. Campbell
____(57AM-3C-2) *Measurements on Polymer-Modified Lubricating Oils at High Rates of Shear,* by W. Philippoff
____(57AM-5C-3) *Mechanism of Tungsten Disulfide Lubrication in Vacuum,* by M. T. Lavik, G. W. Vaughn & G. E. Gross
____(57AM-1C-1) *Micro-Fog Lubrication of Machine Tools,* by D. G. Faust
____(57AM-6B-2) *Mill & Laboratory Evaluation of Oils for Rolling Copper Alloys,* by F. L. Reynolds
____(57AM-5C-2) *Molybdenum Disulfide & Related Solid Lubricants,* by B. C. Stupp
____(57AM-5A-1) *New Developments in Gear Lubricants,* by C. M. Heinen
____(57AM-2C-3) *New Thickener for Multipurpose Lubricating Greases, A,* by W. L. Hayne, D. R. Oberlink & R. J. Rosscup
____(57AM-3C-1) *Non-Newtonian Characteristics of Lubricating Oils, The,* by T. W. Selby
____(57AM-2C-1) *Performance of an Inorganic Microgel Grease in Industrial Applications,* by J. A. Bell
____(57AM-5C-1) *Plastics as Solid Lubricants & Bearings,* by A. J. G. Allan
____(57AM-1B-2) *Preparation of Highly Effective Rust Inhibitors by Fractionation of Mahogany Sulfonates,* by K. R. Fisch, J. Messina & H. Gisser
____(57AM-5A-2) *Problems Associated with the Development & Marketing of Gear Lubricants,* by A. A. Manteuffel & J. B. Stucker
____(57AM-5B-4) *Railroad Lubricants — Their Storage & Handling,* by C. M. Larson
____(57AM-5A-3) *Rear Axle Problem — Initial Axle Noise, A,* by J. E. Cardillo
____(57AM-4A-4) *Review of Recent Russian Research on Chemisorbed Lubricant Films,* by D. Godfrey
____(57AM-2C-2) *Service Experience with a New Multipurpose Industrial Grease,* by S. R. Calish, Jr.
____(57AM-1B-1) *Some Effects of Gamma Radiation on Commercial Lubricants,* by J. G. Carrol & S. R. Calish, Jr.
____(57AM-2B-3) *Some Mechanical Considerations in the Design of Large Thrust Bearings,* by R. A. Baudry & G. E. Peterson
____(57AM-4B-1) *Standardization of Plant Lubricants & Lubrication Practices,* by R. O. Kageff
____(57AM-5C-4) *Teflon for Dry Lubricant Bearings,* by S. B. Twiss, P. J. Willson & E. J. Sydor
____(57AM-4A-3) *Theoretical Criteria for the Effectiveness of a Lubricant Film,* by E. Rabinowicz
____(57AM-2A-4) *Threading Test for Cutting Oil Evaluation, A,* by H. A. Hartung, J. W. Johnson & A. C. Smith, Jr.
____(57AM-1C-2) *Vacuum Dehydration of Oils,* by G. J. Topol
____(57AM-6B-1) *Wear & Frictional Characteristics of Some Wrought & Cast Nickel-Base Alloys,* by R. A. Kozlik
____(57AM-1A-1) *Wear of Carbon-Type Seal Materials with Varied Graphite Content,* by M. A. Swikert & R. L. Johnson

(Please Print)

Name . . . . . .

Address . . . . . .

. . . . . .

. . . . . .

susceptibility is apparently caused by the presence of three ternary carbon atoms, particularly the tertiary carbon bound to the methyl group, these being active centers for oxygen attack during the initial period of oxidation.

The oxidation of *n*-heptylcyclohexane differed from that of α-methyldecalin in the formation of larger amounts of asphaltenes and in not producing carboids or asphaltenes insoluble in ethyl ether. The asphaltenes are products of further condensation of resins under the action of oxygen. Luminescent analysis indicated that oxidation of *n*-heptylcyclohexane proceeds more slowly and has a longer induction period than in the case of α-methylcyclohexane.

The major oxidation products of heptylbenzene were low-molecular weight oxygen compounds (33.2%) resulting from oxidation cleavage of the molecule. The formation of large quantities of benzaldehyde and benzoic acid indicates that the oxygen enters the side chain to form a hydroperoxide, presumably on the side chain carbon attached to the ring. Breakdown of this hydroperoxide gives the aldehyde and acid. The side chain fragment and the aldehyde may then give rise to condensation products. Benzoic acid was found after 25 hours, while after 50 hours unsaturated compounds were also detected.

The oxidation of *n*-hendecene-1 differed from that of the hydrocarbons cited above, presumably because of the presence of an olefinic double bond in the molecule. No asphaltenes were found in the oxidation end products and the resins, comprising 85% of the oxidation products, were quite reactive; they underwent condensation during silica gel chromatography during which their molecular weights doubled. Formaldehyde and small quantities of formic acid were detected among the oxidation products. This observation together with essentially complete conversion of the original olefin to condensation products indicates that oxygen attack on the double bond is of secondary importance. The major reaction is believed to be its oxidative polymerization under the influence of peroxides. Because of its unsaturation, *n*-hendecene-1 gave high molecular weight condensation products earlier in the oxidation process than was observed with the other hydrocarbons. (*Reviewed by H. D. Orloff*)

"Rheological Studies of Lubricating Greases," by R. Krause, *Erd. Kohle, Vol. 9*, 1956, pp. 241-245.

A rotation-viscometer of the Couette type is used to determine the flow curves of various types of greases. This instrument consists basically of an outer cylinder in which the sample to be studied is contained and an inner cylinder. The outer cylinder can be subjected to a rotational motion varying gradually from 0 to a given maximum rpm. This motion is transmitted by the sample to the inner cylinder. The motion of this inner cylinder is recorded graphically in such a way that the velocity gradient (shear rate) appears as ordinate and the shear stress as abscissa. The resulting plot represents, therefore, directly the flow curve of a grease. By comparing the tracings obtained when rotating the outer cylinder from zero to the maximum rpm and back to zero, information is obtained on the ability of the grease structure to heal. The results obtained with three greases are used to show that the flow curves produced by the instrument correspond closely to the plots usually obtained from a multitude of single, time-consuming determinations. Using appropriate heating arrangements, it is also shown that the effect of temperature on the apparent viscosity of a grease can be studied. (*Reviewed by E. O. Forster*)

"Studies of Artificial & Natural Aging of Non-Additive Lubricating Oils," by G. Spengler & H. O. Hoessl, *Erd. Kohle, Vol. 9*, 1956, pp. 686-690.

Two non-additive petroleum lubricating oils were aged artificially by the Indiana, MAN (a static air oxidation procedure), and Sligh oxidation tests and in cars in 1,000 mile road tests. Aging increased the naphthene content and decreased the aromatics and paraffin content of the oils. The course of the reaction apparently differs with the aging procedure. The main oxidation products, naphthenes and aromatics, inhibited resin formation. Aging stability was better in a regenerated oil than in new oils and decreased when the aromatics were completely removed. No definite relation between hydrocarbon type and aging stability was established. The results of the 2.5 hr. Sligh test and the 75 hr. MAN test were similar to those obtained in road tests, but the 24 hr. Indiana test was too severe for comparison. The changes in oil composition observed in Opel and Porsche cars were similar to those shown in artificial aging tests, but the course of oxidation in the Volkswagen appeared different. (*Reviewed by E. O. Forster*)

"Study of the Film Strength of Lubricating Oils in Bearings as a Function of Load & Speed," by E. Terres, G. Morlock & K. H. Voelker, *Erd. Kohle, Vol. 9*, 1956 pp. 597-601 & 690-693.

I. Formulation of Problem, Lubricants & Test Apparatus

A machine for testing the film strength of lubricating oils has been built, which consists of a sleeve-type bearing which is pressed up against a rotating shaft by a hydraulic press. By changing the rpm at constant load, it is possible to make measurements under hydrodynamic as well as mixed boundary-hydrodynamic conditions. The film strength is determined from the maximum rpm at which rupture of film and hence metal-to-metal contact occurs. This film rupture is detected electrically.

II. Description of Experiments & Error Analysis

Thirty-eight oils of different origin and having different viscosities as well as different V.I.'s have been evaluated in the test machine at 20, 30, 40, and 50°C. Included in this study were also blends of the base oils with such additives as are commonly used in the preparation of HD oils. The base oils of similar origin showed a direct proportionality between viscosity and film strength. The addition of additives such as V.I. improvers, oxidation inhibitors, or detergents, reduced the film strength of the base oil. An analysis of errors indicated that the error in determining the rpm at which film rupture occurs ranges from ±2.5% for light oils to ±5% for high-viscosity oils. (*Reviewed by E. O. Forster*)

(Lube Lines, from p. 267)

- Non-staining and non-smudging during rolling, annealing, or other processing.
- Easy and economical removal prior to coating. Polarity is important in this regard.

ASLE Directory

NATIONAL OFFICERS

President

J. O. McLean.....Reynolds Metals Co.

Vice-President at Large

J. D. Lykins.....Wheeling Steel Corp.

Secretary

J. L. Finkelmann....Chrysler Corp., Cycleweld Div.

Treasurer

J. W. Peterson.....Standard Oil Co. (Ind.)

Administrative-Secretary

C. L. Willey.....ASLE National Office

Chrmn., Presidential Council

E. R. Booser.....General Electric Co.

NATIONAL DIRECTORS

S. R. Calish, Jr. .....California Research Corp.
D. M. Cleaveland.....Bendix Aviation Corp.
J. H. Fuller.....E. I. du Pont de Nemours & Co.
B. T. Harding .....Midwest Oil Co.
C. T. Lewis.....Republic Steel Corp.
D. W. Sawyer.....Aluminum Co. of America
A. B. Two .....Ford Motor Co.
L. O. Witzenburg .....The Farval Corp.

REGIONAL VICE-PRESIDENTS

R. C. Dishington (W) .....General Petroleum Corp.
M. E. Dougherty (E).....Acheson Colloids Co.
T. A. Marshall (Can.) ....Steel Co. of Canada, Ltd.
R. F. McKibben (Central)..Nat'l Cash Register Co.
A. B. Wilder (MW) .. E. I. du Pont de Nemours & Co.

NATIONAL COMMITTEE CHAIRMEN

Abstracts .....W. E. Campbell, Afram Consultants
Annual Meeting (Cleveland) .....E. J. Gesdorf, The Farval Corp.
Annual Meeting Sites .....J. D. Lykins, Wheeling Steel Corp.
Awards.....D. W. Sawyer, Aluminum Co. of America
By-Laws .....A. E. Cichelli, Bethlehem Steel Co.
Editorial .....R. K. Gould, The Texas Co.
Education .....B. G. Rightmire, Massachusetts Institute of Technology
Finance.....C. C. Blaisdell, Penola Oil Co.
Handbook Advisory .....C. R. Schmitt, E. F. Houghton & Co.
Historian .....W. G. Fatch, U. S. Steel Corp.
Industrial Membership.....C. L. Willey, ASLE National Office
Journal Bearing Research .....E. M. Kipp, Aluminum Co. of America
Lubrication Conference .....E. E. Bisson, National Advisory Committee for Aeronautics
Membership & Admission .....B. M. Dunham, Sun Oil Co.
New Sections.....C. L. Willey, ASLE National Office
Nominations .....E. R. Booser, General Electric Co.
Program (Annual Meeting — Cleveland) .....H. W. McCulloch, Jr., Shell Oil Co.
Projects .....R. A. Kraus, Republic Steel Corp.
Tellers.....R. G. Grothus, Bell & Howell Co.

TECHNICAL COMMITTEE CHAIRMEN

Technical Advisory Board .....A. A. Raimondi, Westinghouse Electric Co.
Bearings & Bearing Lubrication.....A. A. Raimondi, Westinghouse Electric Co.
Engine Lubrication .....N. C. Penfold, Southwest Research Institute
Fluids for Metal Working.....H. E. Baker, Jr., General Electric Co.
Gears & Gear Lubrication.....T. W. Havely, Shell Oil Co.
Hydraulics & Hydraulic Machinery.....R. L. Leslie, Vickers, Inc.
Lubricant Reclamation & Disposal .....A. B. Two, Ford Motor Co.
Lubrication Equipment.....E. M. Higgins, Master Lubricants Co.
Lubrication Fundamentals .....D. Godfrey, California Research Corp.
Lubrication Practices .....R. J. Torrens, Eastman Kodak Co.
Machine Tools .....W. D. Whalen, R. K. LeBond Machine Tool Co.
Nonferrous Metals .....L. H. Decker, Revere Copper & Brass Inc.
Properties of Lubricants .....C. W. Nichols, Jr., Socony Mobil Oil Co., Inc.
Seals & Packings.....R. W. Blair, Chicago Rawhide Mfg. Co.

AREA REPRESENTATIVES

Boston/Connecticut .....H. A. Wilson, Commercial Filters Corp., 30 Coolidge Ave., Lexington, Mass.
Buffalo/Schenectady/Syracuse .....D. F. Wilcock, General Electric Co., Gen. Engrg. Lab., 1 River Rd., Schenectady, N. Y.
Chicago/Milwaukee/Rockford .....F. J. Schmitt, D. A. Stuart Oil Co., 2727 S. Troy St., Chicago, Ill.
Cleveland/Youngstown .....A. H. Turner, Standard Oil Co., Midland Bldg., Cleveland 15, Ohio
Columbus .....H. W. Irion, National Refg. Co., 1885 Coventry Rd., Columbus 12, Ohio
Dayton/Cincinnati .....G. H. Leffel, D. A. Stuart Oil Co., 1021 N. Limestone St., Springfield, Ohio
Houston/Dallas/Fort Worth .....F. A. Rudolph, Sun Oil Co., 840 Rio Grande, Dallas 1, Tex.
Indianapolis/Fort Wayne .....D. H. Wilson, Continental Steel Corp., South Plant, Kokomo, Ind.
Kansas City/St. Louis .....C. J. Smith, Cities Service Oil Co., 406 W. 34th St., Kansas City, Mo.
Los Angeles .....R. C. Dishington, General Petroleum Corp., 2401 E. 27th St., Los Angeles 54, Calif.
New York/Baltimore/Philadelphia .....M. E. Dougherty, Acheson Colloids Co., 1423 Land Title Bldg., Philadelphia 10, Pa.
Pittsburgh/Wheeling .....J. P. Critchlow, Gulf Oil Corp., Gulf Bldg., Pittsburgh 30, Pa.
Seattle/Washington .....J. Hood, Boeing Airplane Co., 2906 - 39th Ave., SW, Seattle 16, Wash.
Twin Cities/Duluth/Iron Range/Davenport/Rock Island/Des Moines/Cedar Rapids
R. O. Erickson, Shell Oil Co., 5516 Glengarry Pkwy., Minneapolis 24, Minn.
Western Rocky Mountain .....D. P. Thomas, Columbia-Geneva Steel Div., U. S. Steel Corp., P. O. Box 510, Provo, Utah

SECTION CHAIRMEN

Baltimore .....R. L. Humphreys
Boston .....E. G. Jackson
Buffalo.....V. Steele
Central Ohio.....H. W. Irion
Chicago.....R. G. Grothus
Cincinnati.....R. W. Smith
Cleveland.....E. F. Rost
Connecticut.....P. Faxon
Dayton .....H. L. Sellers
Detroit.....J. A. Brady
Duluth/Iron Range.....R. D. Keech
Fort Wayne.....C. R. Griffith
Houston.....M. P. Murphy
Indianapolis.....C. M. Marlatt
Inter-Mountain .....D. P. Thomas
Kansas City.....R. H. Cottrell
Kingsport .....T. R. Witt
Los Angeles .....R. F. Connelly
Louisville.....C. A. White
Milwaukee.....J. A. Gramling
Mohawk-Hudson.....H. Apkarian
Montreal.....R. D. Poole
New York.....D. B. Gordon
N. California.....R. H. Decker
Ontario.....J. F. Parker
Philadelphia.....R. W. Clark
Pittsburgh.....W. G. Ritter
Puget Sound .....C. D. Cummins
Saginaw Valley.....R. P. Schreiber
St. Louis.....G. W. Schall
Twin Cities.....D. L. Heimes
Wheeling.....C. Billingsley
Youngstown.....D. E. Whitehead

SECTION SECRETARIES

Baltimore.....H. A. Rau, Jr., Shell Oil Co., 909 E. 22nd St., Baltimore 18, Md.
Boston .....C. S. Mercer, Morgan Construction Co., 15 Belmont St., Worcester, Mass.
Buffalo.....J. A. Eckardt, Esso Std. Oil Co., 300 Bernhardt Dr., Snyder 26, N. Y.
Central Ohio.....M. Ray, Marble Cliff Quarries Co., 2100 Tremont Cntr., Columbus, Ohio
Chicago .....E. W. Drummond, Interntl. Harvester Co., 5225 S. Western Blvd., Chicago 9, Ill.
Cincinnati .....E. L. Curtis, 3 Sylvan Lane, Cincinnati 15, Ohio
Cleveland .....G. L. Smith, 2461 Noble Rd., Cleveland Heights 21, Ohio
Connecticut.....L. Edwards, Gulf Oil Corp., 68 Carmel St., Hamden, Conn.
Dayton .....H. A. Bradley, 3600 Hertland Dr., Dayton 9, Ohio
Detroit.....C. F. Cowley, Fiske Bros. Refg. Co., P. O. Box 5025, Detroit 35, Mich.
Duluth/Iron Range .....C. D. Johnson, Box 834, Hoyt Lakes, Minn.
Fort Wayne.....J. M. Olson, 4301 SE Anthony Wayne Dr., Fort Wayne, Ind.
Houston.....T. L. Gordy, Continental Oil Co., P. O. Box 2197, Houston, Tex.
Indianapolis .....G. H. Pearson, Jr., 6244 E. 25th St., Indianapolis, Ind.
Inter-Mountain....D. W. Richardson, Utah Power & Elec. Co., P.O. Box 899, Salt Lake City, Utah
Kansas City .....J. D. Jenkins, Box 1099, Kansas City, Mo.
Kingsport .....M. L. Robinette, Tennessee Eastman Co., Kingsport, Tenn.
Los Angeles.....Edna M. Sterling, Richfield Oil Corp., 555 S. Flower St., Los Angeles, Calif.
Louisville.....J. K. Wyatt, Standard Oil Co. (Ky.), 430 W. Bloom, Louisville 8, Ky.
Milwaukee .....R. K. Johnson, Best Engrg. Co., 1504 W. National Ave., Milwaukee 4, Wis.
Mohawk-Hudson.....E. S. Preble, Greenbush Ave., E. Greenbush, N. Y.
Montreal .....K. Bloxham, Can. Pratt & Whitney Aircraft Co., Longueuil, Q, Can.
New York .....M. M. Gurgo, Esso Standard Oil Co., 151 Hamiltonian Dr., Red Bank, N. J.
N. California.....G. H. Hommer, 1271 Mt. Diablo St., Concord, Calif.
Ontario .....W. H. Mann, D. A. Stuart Oil Co., 3575 Danforth Ave., Toronto, Ont., Can.
Philadelphia .....F. L. Heist, E. F. Houghton & Co., 303 W. Lehigh Ave., Phila. 33, Pa.
Pittsburgh .....M. Parker, E. F. Houghton & Co., Bessemer Bldg., Pittsburgh 22, Pa.
Puget Sound .....O. E. Sheppard, Boeing Airplane Co., Seattle, Wash.
Saginaw Valley .....W. A. Mason, Shively Bros., Inc., 3606 Comanche Ave., Flint, Mich.
St. Louis .....E. R. Harris, Alemite Co., 4603 McRee, St. Louis 10, Mo.
Twin Cities.....C. H. Sweet, Minneapolis-Moline Co., Box 1050, Minneapolis, Minn.
Wheeling .....S. J. Litten, Sun Oil Co., 910 Pearl, Martins Ferry, Ohio
Youngstown .....W. E. McGaffney, 3209 Meredyth Lane, Youngstown 11, Ohio

ASLE Publications
ORDER BLANK

Interpreting Service Damage In Rolling Type Bearings

A manual on ball and roller bearing damage which includes drawings, tables, and 74 photographs for aiding in the classification and identification of the causes of many of the common types of bearing damage. $1.00 per copy.

"Lubrication Engineering" Decennial Index

Subject & Author Indexes listing the papers published in **"Lubrication Engineering,"** Journal of the American Society of Lubrication Engineers, in Volumes 1 thru 10 (1945 thru 1954). 50c per copy.

Petroleum-Type Hydraulic Fluids

Second in the series of ASLE monographs, covering Hydraulic Oil Specifications & Service Properties, Viscosity, Viscosity Index, Demulsibility, Oxidation Stability, Lubricating Value, Rust & Corrosion Preventive Qualities. $1.00 per copy.

Physical Properties Of Lubricants

First in the series of ASLE monographs, covering Viscosity, Density & Specific Gravity, Cloud & Pour Points, Flash & Fire Points, Carbon Residue, Neutralization Number & Interfacial Tension, Saponification Number, Emulsification, Specific Heat. $1.00 per copy.

Practical Lubrication, Vol. 1

Ten practical articles giving information fundamental to the carrying out of successful lubrication practices in industry: Cleaning Lubrication Systems, Coal Mine Lubrication, Grease Lubrication of Ball Bearings, Lubricating Grease, Lubrication Requirements of Gears as Seen by a Gear Engineer, Open Gear Lubrication, Planned Lubrication as a Part of Plant Maintenance, Reduction of Gear Failures, Seals & Closures, Steel Mill Lubrication from Management's Point of View. $1.00 per copy.

Indicate opposite title the number of copies desired, fill in your name and address, enclose remittance, and mail to:

ASLE, 84 E. Randolph St., Chicago 1, Ill.

Name.....

Address.....

.....

(Please Print)

Advertisers' Index

Acheson Colloids Co. 251
Alemite Div., Stewart-Warner Corp. 263
Alpha Molykote Corp., The 266
Baroid Div., National Lead Co. 256
Bryton Chemical Div., Continental Oil Co. 258
Climax Molybdenum Co. 264
Emery Industries, Inc. ..... 296 & 297
Farval Corp., The ..... (Inside Front Cover)
Hodson Corp., The ..... (Back Cover)
Houghton & Co., E. F. ..... 254 & 255
International Lubricant Corp. 260
Lincoln Engineering Co., Div. of The McNeil Machine & Engineering Co. 294
Norgren Co., C. A. 268
Sun Oil Co. 252
Trabon Engineering Corp. ..... (Inside Back Cover)
Tuthill Pump Co. 293

Classified 304

THE FRANKLIN INSTITUTE

LABORATORIES FOR RESEARCH & DEVELOPMENT

needs engineers

FOR

PIONEERING WORK

IN

HIGH SPEED - HIGH TEMPERATURE

And

GAS LUBRICATED BEARING APPLICATIONS

Exceptional opportunities for advancement

Send resume to:

PERSONNEL DIRECTOR

PHILA. 3, PA.

TRABON

WITH ORIGINAL "METERFLO"

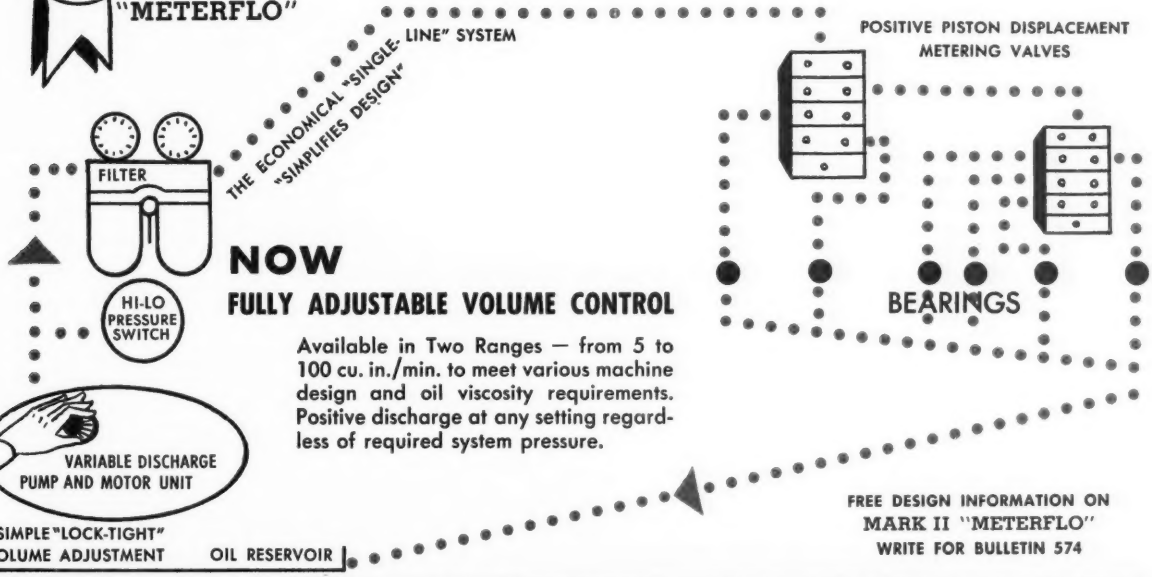
Announces...

MARK II

"METERFLO"

CIRCULATING OIL LUBRICATION SYSTEM

POSITIVE OIL FLOW TO EVERY BEARING UNDER PRESSURE



NOW

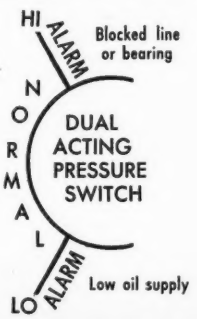
FULLY ADJUSTABLE VOLUME CONTROL

Available in Two Ranges — from 5 to 100 cu. in./min. to meet various machine design and oil viscosity requirements. Positive discharge at any setting regardless of required system pressure.

FREE DESIGN INFORMATION ON MARK II "METERFLO"
WRITE FOR BULLETIN 574

PLUS CALIBRATED DUAL PRESSURE SWITCH EQUIPMENT

Compact dual-acting pressure switch now includes calibrated adjustment for simple and ready adaptation to meet all field conditions. "Pressure - dampened" switch and gauge equipment—for longest equipment life and elimination of any momentary "false" pressure signals.



Wide normal operating range assures positive metered quantity **regardless of length of line or varying bearing resistances.**

TRABON ENGINEERING CORPORATION
28815 AURORA ROAD SOLON, OHIO

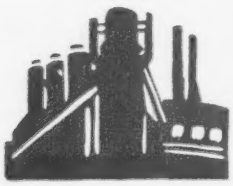
NOTE TO MACHINE DESIGNERS

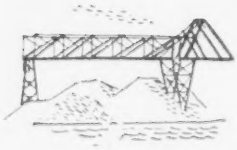
- Hi-Pressure dual cartridge filter — a turn of the handle permits cartridge change without stopping system—"quad" ring seal construction for leak-proof operation.
- Wide range metering valve sizes for ultra-fine metering requirements (i.e. exposed sliding surfaces)—plus accurate control over output ratios of 20-1 and higher within the same system.
- Protection against failure of oil to reach bearings for **any** reason.
- Constant positive pressure feed regardless of change in temperature or oil viscosity.
- "Packaged" power units—complete sump, pump, and control units available in any desired combination.

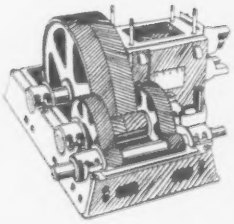
For further economy, non-adjustable units also available.

HODSON

"FOUR HORSEMEN" LUBRICANTS ®







These exclusive products have been developed to meet the major lubrication needs of steel mills, rubber plants, cement mills, paper mills, brass and copper mills, mines, forging shops, machine shops, ore and coal handling docks, bridges, printing plants, container and drum plants, canning and food processing plants and railroads.

Hodson "Four Horsemen"® lubricants have been originated and formulated by lubrication engineers, developments resulting from long and varied experience in the mechanics of specialized lubrication.

The HODSON CORPORATION

Lubrication

5301-11 WEST SIXTY SIXTH STREET

CHICAGO 38, ILLINOIS

5-L-57

PRINTED IN U.S.A.